THE UNIVERSITY OF ALBERTA

AFFECTIVE AND COGNITIVE BEHAVIORS OF STUDENTS AS RELATED TO TEACHING MODE CHARACTERISTICS

by

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A DISSERTATION

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF SECONDARY EDUCATION

EDMONTON, ALBERTA

FALL, 1976

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled [illegible] submitted by [illegible] in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

Supervisor

External Examiner

Date September [illegible]

DEDICATION

The degree for which this dissertation
was presented is dedicated
to my family

L. M. & R. C. Gay
Marie, Michelle and Marni

ABSTRACT

The purpose of this study was to develop a method of describing science learning situations in terms of teaching mode characteristics, and subsequently to use these descriptions in predicting specific student cognitive and affective behaviors.

Science learning situations were viewed in terms of how inquiry-oriented the teachers in the sample were perceived to be by: the teachers themselves, their students and external personnel. Using these perceptions, the teachers were categorized into high, medium or low levels of inquiry-orientedness and the performance on cognitive and affective attribute measures of students of high inquiry-oriented teachers was compared with the performance of students of low inquiry-oriented teachers.

Subsequently, students who indicated a desire for a high inquiry-oriented science learning situation were compared with students who indicated a desire for a low inquiry-oriented situation on several affective and cognitive criterion measures. Finally, the student's perception of his actual science learning situation compared with his perception of a desired science learning situation was used to yield the degree of congruence or match between the two perceptions. The degree of match was used as a predictor of student performance on the criterion measures.

Results of the analysis yielded implications for methodologies of identifying teaching mode characteristics, relationships between different science learning situations and cognitive and affective behaviors

ABSTRACT

The purpose of this study was to develop a method of describing science learning situations in terms of teaching mode characteristics, and subsequently to use these descriptions in predicting specific student cognitive and affective behaviors.

Science learning situations were viewed in terms of how inquiry-oriented the teachers in the sample were perceived to be by: the teachers themselves, their students and outside observers. Using these perceptions, the teachers were categorized into high, medium or low levels of inquiry-orientedness and the performance on cognitive and affective criterion measures of students of high inquiry-oriented teachers was compared with the performance of students of low inquiry-oriented teachers.

Alternatively, students who indicated a desire for a high inquiry-oriented science learning situation were compared with students who indicated a desire for a low inquiry-oriented situation on several affective and cognitive criterion measures. Finally, the student's perception of his actual science learning situation compared with his perception of a desired science learning situation was used to yield the degree of congruence or match between the two perceptions. The degree of match was used as a predictor of student performance on the criterion measures.

Results of the analysis yielded implications for methodologies of identifying teaching mode characteristics, relationships between different science learning situations and cognitive and affective measures

of students and results of matching students with their desired science learning situation.

One of the findings was that the learning environment can be described in terms of inquiry-orientedness as defined in this study; the source of the description appears to be an important variable for prediction purposes. It appears none of the sources, the student, the teacher or the teacher's associate, is very adequate for predicting student cognitive behaviors when the classroom is taken as the unit of study. However, the individual student's view of his science learning situation is statistically significant as a predictor of his affective and cognitive behaviors.

When the students' individual perceptions of their science learning situations were used for predicting student attributes, information regarding their desire for high or low inquiry-oriented instruction and whether or not they were actually getting the type of instruction they desired resulted in two major findings: 1) When significant differences in performance on attribute measures were found, students who prefer high inquiry-oriented science learning situations perform better than students who prefer low inquiry-oriented situations, and 2) When students were classified as matched or not matched to their desired science learning situation the four resultant groups performed differently. When significant differences were found, the high inquiry matched group usually performed best on all affective and cognitive instruments, the high inquiry unmatched group performed second best on

cognitive-oriented instruments, the low inquiry matched group performed second best on attitude instruments, and the low inquiry unmatched group usually performed poorest on all instruments.

ACKNOWLEDGEMENTS

It is impossible to acknowledge all the people who encouraged and assisted me over the years since this study was begun. However, I wish to convey my thanks to all those special individuals whose understanding and encouragement has meant the difference between success and failure.

I wish to express my appreciation to Dr. M.A. Nay, Mrs. Nay and Dr. H. Kass whose support, encouragement, guidance, understanding and friendship helped me to bring the study to a successful conclusion. I also wish to thank the other members of my committee, both past and present for their recommendations, patience and understanding through the long years: Drs. Maguire, MacArthur, Dunford, Hollebone, Jacknicke, Gupta. Thanks is also extended to those in the Faculty of Education who provided much needed advice and encouragement.

I sincerely thank the secretaries in the Grande Prairie and Calgary Regional Offices of Education without whose help the data collection, organization and typing would have been impossible. I am similarly indebted to many senior executives and colleagues in the Department of Education whose continuing support, assistance and patience encouraged me to see the project through to its conclusion. Also, a special thanks to Keith Fenske for the assistance in the extensive computer work required for the study.

A debt of gratitude is acknowledged to those teachers whose professionalism made this study possible.

A special thanks is extended to my typist, Audrey Neufeld, whose long hours of work made possible the completion of the project.

A very special thanks to my family for their unselfish understanding, support and cooperation during the duration of this study.

G. R. G.

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CHAPTER I

INTRODUCTION TO THE STUDY

This chapter introduces and describes the nature of the study. Subsequent chapters provide a review of the literature contributing to the theoretical framework of the study (Chapter II); the research design, including the pilot work which contributed to the study (Chapter III); results, analysis and discussion (Chapter IV); and a summary, including conclusions and implications (Chapter V).

Background of the Study

The teacher in the classroom must be concerned with many variables while being involved in science teaching-learning situations. Among these variables is the continuous introduction of new methods of presentation, usually through new science curriculum material (e.g. textbooks, individual study kits, audio visual aids). Inherent in many of these materials are philosophies of science teaching and instructional approaches which the teacher presumably must follow if the instructional aims of the new materials are to be achieved. A major question about the materials relates to the actual effect they have on the development of students' understandings and attitudes. For example, one might ask, are these materials sufficiently congruent in their philosophy of science teaching and instructional approach with the way most teachers teach and most students learn?

It would be desirable to know whether certain teaching styles or

teaching mode characteristics are associated with particular student behaviors or variables such as I. Q., course grades, attitudes and understanding of science and scientists. Concomitantly, it would be desirable to know if different students desire or require different teaching modes or approaches. To answer these questions there is a need to develop a method of identifying this association.

Intelligence and achievement tests are the most commonly used instruments for measuring student performances but since they have specified limited purposes they do not give a sufficient insight into the association between teaching mode characteristics and the whole range of student behaviors or variables mentioned above, nor have the limited number of attitude instruments and tests on the nature of science which have been developed to date been utilized to maximum advantage in studying this association.

The thrust of this study, therefore, is to identify appropriate instruments already available, and to develop new ones where needed, for measuring teaching mode characteristics and student attributes, and further, to devise a method of determining the association or relationship between them. If this association becomes well understood it could enable a classroom teacher to select those teaching and learning approaches which will maximize his chances of developing given attributes in a given student. It may enable him to adapt better new curriculum materials to the science learning situation desired by each student.

Some of the student behaviors of concern in this study have been indicated in the objectives for junior high school science in Alberta (Curriculum Guide, pp. 1-3) as follows: 1) development of humanistic

and social implications of science, 2) the development of process and motor skills, 3) the development of student attitudes that are in harmony with the spirit of scientific investigations and 4) the development of basic science concepts. The objectives, "To develop attitudes, interests, values, appreciations, and adjustments similar to those exhibited by scientists at work" is found in the statement of objectives for secondary school science in Alberta (Curriculum Guide, p. 2).

Objectives in science education frequently state, or at least imply, the methodology by which the goals should be obtained. For example, the Alberta Curriculum Guide (Curriculum Guide, pp. 7-11) lists desired student skills and attitudes and suggests activities for developing them. Pedagogical considerations such as these stem from the dynamics of the curriculum reform movement in science of the 1960's and the curriculum theory in vogue at that time such as: Gagne's statement that students should learn processes (1963, p. 153), Schwab's comments on the importance of the structure of the disciplines (1966, p. 32), Parker and Rubin's thesis on the importance of considering process as content (1968). Welch and Pella not only support these statements but add the important dimension of evaluation of achievement of objectives when they state "An objective of science is to develop understanding of the methods and processes by which scientific knowledge evolves - and real objectives must be tested objectives" (1969, p. 68). Hence objectives intrinsically demand the need for appropriate evaluation devices.

Although statements of objectives from curriculum guides and leading science educators indicate the need for development of several domains and areas of behavior in students (cognitive, affective, psycho-

motor, process), inadequate attention has been given to the method of their implementation in a science classroom. Furthermore, little is known about the interaction of the affective, cognitive, psychomotor and process areas or domains, and the specific teaching modes and instructional materials that must be employed to achieve objectives in these domains and the evaluation techniques that can be used to assess the level of their achievement.

To study these variables, it is helpful to identify, a priori, the relationships between domains of objectives, instructional and learning strategies and evaluation procedures. Some assistance for developing a model for their relationship can be obtained from the research literature. Raun and Butts (1967-68, p. 262) have developed a model (see Figure 1) for indicating the interactions of the strategies of inquiry in science with the affective and cognitive domains.

This model illustrates the systems approach with the strategies of inquiry in science or teaching mode being central. The basic question then is, "Does student interaction with the strategies of inquiry or teaching mode affect the student behavior in the cognitive domain, the affective domain, in both, or in neither?" The model in Figure 1 conceptualizes these possible relationships. As well, to complete the system, the model indicates "feedback effects which might influence interaction in subsequent school years or in another curriculum organization" (Raun and Butts, 1967-68, p. 262).

Raun and Butts center their study on the hypothesis that if the student is exposed "to situations which focus on inquiry and student involvement, then certain changes should occur in student cognitive and

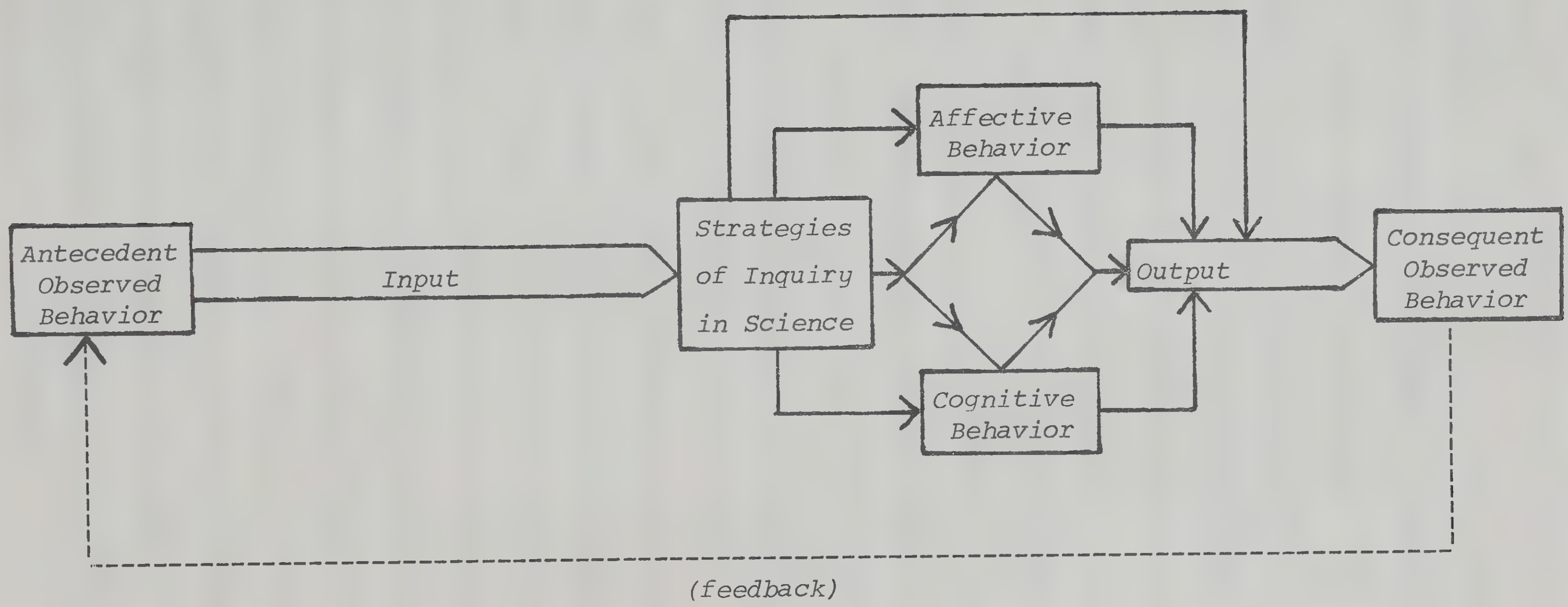

Figure 1

Model of Interaction of Strategies in Inquiry and Affective and Cognitive Behavior of Students

affective behaviors as a consequence of interacting with the strategies of inquiry or a curriculum" (1967-68, p. 262). In the classrooms used in the present study there will be a great variety of instruction, some of which will not involve strategies of inquiry to a significant degree. Therefore, for the purpose of the present study it is necessary to consider "levels" of inquiry in classroom instruction. To facilitate the determination of the nature of instruction that goes on in each classroom, it is more appropriate to use the notion of <u>teaching mode characteristics</u> (TMC) than "strategies of inquiry". A review of the literature of inquiry teaching yields a set of characteristics which depict the inquiry mode (Appendix A). A key element in these characteristics is process-skill development (e.g. hypothesizing, problem definition, observing, inferring). These inquiry mode characteristics are used to develop instruments for determining the teaching mode characteristics of the classrooms represented in the study.

Thus, in the model representative of the present study (Figure 2) strategies of inquiry are replaced by the idea of teaching mode characteristics (TMC). The focus in the present study is on the effect that the specified TMC have on student affective and cognitive attributes. In addition to focusing on strategies of instruction, the present study takes into consideration the student's <u>desire</u> for a particular set of teaching mode characteristics. That is, not only will the effect of <u>actual</u> teaching mode characteristics on the student's affective or cognitive behaviors be measured, but as well, the effects in these domains of the student being exposed to teaching mode characteristics of his choice will also be explored.

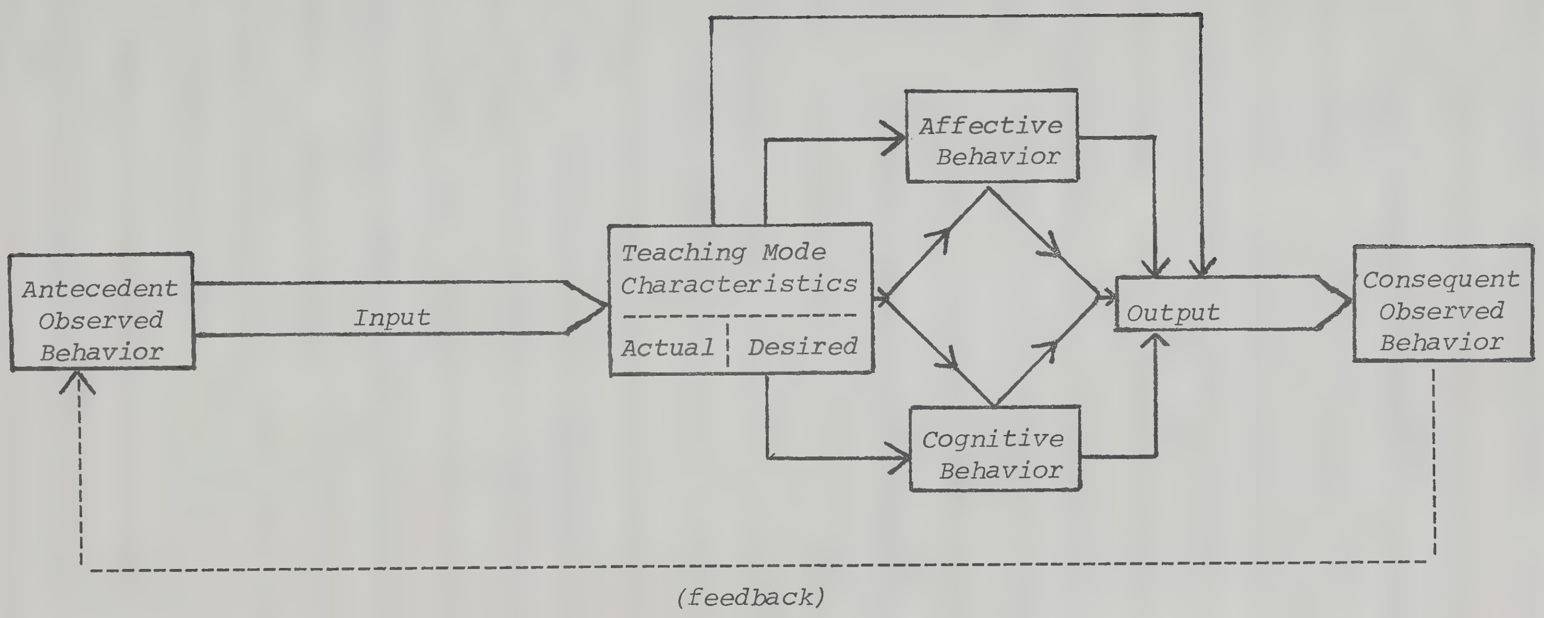

Figure 2

Model of Interaction of Teaching Mode Characteristics with Affective and Cognitive Behavior of Students

Another element in this study is to compare the perceptions of different clientele (teachers, students, teachers' associates, external examiners) of the teaching mode characteristics of the science classrooms. Of the clientele mentioned, the research (Walberg, 1969b, p. 444; Costin and Menges, 1971, p. 535; Cheong and Devault, 1966, p. 449) shows that the individual student's perception of the learning environment is increasingly supported over other descriptive methods such as that of an external evaluator. In fact, Walberg (1969b, p. 444), for various reasons to be discussed later, favors student ratings over many "behavioral scales and observation schedules" for describing different classroom situations. With respect to predictive validity, Walberg points out that "few studies have reported significant predictions of learning from them (Medley and Mitzel, 1963), and these few have failed to account for substantial variance, say 20%, in the learning criteria (1969b, p. 444)". As well, Walberg criticizes these external observation devices on the basis that they largely tap teacher behavior and focus on frequency rather than the relative <u>intensity</u> of acts such as rewards. For example, a "wink from a grouchy teacher" may be more important than "lots of verbal praise from a teacher conditioned to gush". A stimulus from the teacher affects learning only to the extent that it registers with the learner. Research by Costin and Menges (1971) supports Walberg on the question of reliability, validity and usefulness of student ratings of the learning environment.

Thus the students' perception of the learning environment, particularly of the teaching mode characteristics, is the method which should result in significant findings when the student characteristics or

attributes are compared with the teaching mode characteristics (TMC).

Of particular interest in the student's perception of the TMC is whether or not what he perceives as the actual science learning situation is in fact what he desires. That is, in the view of the student is he matched or mismatched with his science learning situation? Four groups of students result from this comparison of desired and actual science learning situations as indicated in Table 1.

An inherent question resulting from the matching procedure is, "What happens when the desired student learning situation is, or is not, matched with the actual learning situation?" A partial answer is given by the discrepancy studies carried out by Cheong and Devault (1966) with respect to teachers being matched to students. They investigated the relationships between teacher and "ideal"-teacher discrepancies and six dependent variables for elementary school students. Items regarding teacher's habits or characteristics were followed by two questions to which the students responded: "Is my teacher like this?" and "Would I like a teacher like this?" High discrepancies between what the pupil perceived he actually had and his perception of an "ideal" teacher were found in each of the following categories of students: low achievers (boys), low (sociometric) status, low school attitudes, aggressive self concepts (1966, p. 449).

Hunt (1974) also investigated the matching of students and their learning situations. To arrange this match, Hunt (1974, p. 43) describes students in terms of low to high conceptual levels or ability to act independently. A complex set of characteristics is associated with individuals of the various conceptual levels (Hunt, 1974, pp. 208-213,

TABLE 1

MATCHING OF STUDENTS AND THEIR SCIENCE LEARNING SITUATION

		Desired Teaching Mode Characteristics (TMC)	
		High Level of Inquiry	Low Level of Inquiry
Actual Teaching Mode Characteristics (TMC)	High Level of Inquiry	MATCHED (Group 1)	NOT MATCHED (Group 4)
	Low Level of Inquiry	NOT MATCHED (Group 2)	MATCHED (Group 3)

217). Investigating the interactive effects of learner conceptual level (CL) with the degree of structure of his learning environment, Hunt (1974, p. 222) states his basic matching principle, "Low CL learners profit more from high structure and high CL learners profit more from low structure or in some cases, are less affected than low CL learners by variations in structure." The present study will attempt to check this statement.

Hunt's methdology of matching students and learning situation appears complicated and unmanageable for a classroom teacher. Cheong's and Devault's use of discrepancy scores, based on student perception, is a viable method for studying the matching of student learning style to teaching mode characteristics. If this method is developed further it should be able to be used for prediction of performance on measures of various student attributes. Walberg and associates have initiated a series of studies in this area using the classroom as the unit of investigation (Walberg and Ahlgren, 1970, pp. 153-167; Walberg and Anderson, 1968, pp. 414-419; Walberg, 1969b, pp. 443-448; Walberg, 1970, pp. 153-167). Walberg showed that "measures of student perception of classroom environment obtained at midyear predict gains in cognitive, affective and behavioral learning criteria during the school year" (Walberg, 1970, p. 153). These predictions remained when the effect of the covariates I. Q., initial differences in achievement and interest in the subject were subsequently removed from student characteristic measurements. Walberg recommends that his study be expanded to grade levels other than the high school physics classes he studied and to the individual student within the classroom (1969b, p. 449; 1970, p. 166). These

are objectives of the present study.

The model representing the present study, Figure 2, incorporates the previously described variables and procedures: identification of teaching mode characteristics (TMC), student's perception of a desirable environment, and its matching with the actual TMC and the resultant effect on student cognitive and affective behavior.

Statement of the Problem

The purpose of this study is to develop a method of describing science learning situations in terms of teaching mode characteristics and subsequently to use these descriptions in predicting specified student cognitive and affective behaviors.

Science learning situations are viewed in terms of how inquiry-oriented the teachers in the sample are perceived to be by the teachers themselves, by their students and by external personnel. Using these perceptions, the study categorizes teachers into high, medium or low levels of inquiry-orientedness, and compares the performances of students of high inquiry-oriented teachers with the performances of students of low inquiry-oriented teachers on each attribute measure.

Further, the individual students are categorized on the basis of the level of inquiry-orientedness desired in their science learning situation and students who desire a low inquiry-oriented science learning situation are compared with students who desire a high inquiry-oriented one on each behavior measure.

Specifically, the study is designed to obtain answers to the following questions:

1. Which, if any, perceptions of a teacher's science learning situation can be used to predict student attributes in the cognitive and affective domains? Concomitantly, in describing teachers as more or less inquiry-oriented, is high inquiry desirable for prediction of certain attributes in students and low inquiry desirable for prediction of others?
2. Do students who desire a high inquiry-oriented science learning situation perform differently on the cognitive and affective measures than students who desire a low inquiry-oriented science learning situation?
3. Can differences be identified among students classified as being matched or not matched with either high inquiry or low inquiry-oriented science learning situations? That is, are there any differences among the four groups of students identified in Table 1 with respect to their scores on cognitive and affective measures?

A pilot study utilizing nine grade nine teachers and their students (approximately 450) in the Edmonton Public School system was conducted to determine the productivity of research on using TMC to predict student attributes. The pilot study was also used to identify and field test instruments and methodologies which could be utilized to measure the following student behaviors in the cognitive and affective areas: I.Q., science grades, attitudes toward science and school, knowledge of the nature of science and scientists.

In the main study twelve instruments were used to gather data from approximately 130 grade nine teachers and their 4500 students

throughout the Province of Alberta during February through May, 1972. All grade nine teachers in the Province of Alberta were informed of the study and those chosen were picked at random from the 250 who volunteered to participate. For reasons to be stated later, only six teachers and their students (approximately 482) who completed all major questionnaires and tests were used for testing the hypotheses. The major design change from the pilot study was to take the individual student into consideration to enable investigation of matching of student and his learning environment and subsequently to utilize this matching to predict achievement.

Definitions

Teaching Mode Characteristics

Teaching mode characteristics are the composite of those acts, student activities, instructional materials, curriculum, etc. used by a specified teacher which are indicated in the table of "Characteristics of an Inquiry-Oriented Science Learning Situation", Appendix A.

Science Learning Situation Inventory (SLSI)

This instrument is based on selected characteristics from the Table in Appendix A and is used to determine the teaching mode characteristics of a specified teacher. Three parallel forms have been produced, one for the student (SLSI-S), one for the teacher (SLSI-T) and one for the teacher's associate (SLSI-TA).

The SLSI-S version has three subtests: SLSI-TMC, SLSI-A and SLSI-D. The SLSI-TMC subtest contains the majority of items in the

SLSI-S test (see Table 14), the SLSI-A subtest contains selected items which measure the student's perception of his actual science learning situation and the SLSI-D subtest contains items parallel to those used in the SLSI-A subtest and measure the student's desired science learning situation.

Teaching Mode Characteristics (TMC) Score

This is the score used to classify teachers as to degree of inquiry-orientedness. The TMC score for teachers and teacher's associates is the score obtained on the SLSI-T and SLSI-TA tests respectively. The TMC score for students is the SLSI-TMC subtest score. A high TMC score indicates a high degree of inquiry-orientedness.

Discrepancy Score

The SLSI-A yields an A-score and SLSI-D yields a D-score. Higher scores indicate a higher degree of inquiry-orientedness. The difference between the D-score and A-score, that is D - A, is the discrepancy score and is an indication of the degree to which a student is matched with his science learning situation. As indicated in Table 2 this should result in four groups of students with the two matched groups having low discrepancy scores and the two groups not matched having high discrepancy scores.

How I Feel About My School (HIFAMS)

HIFAMS (Pyra, 1965) was developed to ascertain a student's attitudes towards aspects of his school such as his social life, the degree to which the program meets his needs and the helpfulness of

TABLE 2

USING DISCREPANCY SCORES TO INDICATE MATCHING OF STUDENTS TO THEIR SCIENCE LEARNING SITUATION

Group	D-Score	D - A	Result	Description
1	High	D = A	Matched	Want high level of inquiry. Are getting high level of inquiry.
2	High	D ≠ A	Not Matched	Want high level of inquiry. Are not getting high level of inquiry.
3	Low	D = A	Matched	Want low level of inquiry. Are getting low level of inquiry.
4	Low	D ≠ A	Not Matched	Want low level of inquiry. Are not getting low level of inquiry.

teachers. A total test score indicating the student's general attitudes towards his school and six subtest scores indicating the student's attitudes towards specified aspects of his school are utilized in the present study.

Test On Scientific Attitudes (TOSA)

TOSA (Kozlow and Nay, 1976) is based on an Inventory of Affective Attributes of Scientists (Nay and Crocker, 1970) and was developed to test two aspects of attitudinal behavior in science: 1) knowledge of what a scientist would do in a given science situation and 2) what the student would do if he was faced with a similar science situation. Three scores are obtained from this test: 1) a total test score, 2) a subtest score indicating student knowledge of attitudinal behavior of scientists (CCS), and 3) a subtest score indicating student intended action in similar science situations (ICS).

Science Mark

The science mark of each student is that mark, in per cent, received from his teacher indicating the student's proficiency in his grade nine science course.

I.Q. Scores

Lorge-Thorndike or Otis Quick Scoring tests results, as received from each teacher, are used to indicate the I.Q. score for each student.

Test On Understanding Science (TOUS)

Two forms, Ew and Jw, (Cooley and Klopfer, 1961) are used to indicate student's understanding of scientists and the scientific enter-

prise. Each student receives one score from each test.

Student's Attitudes Towards Science (SATS)

SATS (Hedley, 1966) was developed to obtain information on the degree of student satisfaction with his science course. A total test score is used for each student in the present study.

Sequential Tests of Educational Progress (STEP)

The Science, Form 3A STEP test (Cooperative Science Tests of Educational Progress, 1962) was used to give students a score on general science knowledge.

Hypotheses

The design of the study is based on the following null hypotheses:

Hypothesis 1 (H_1):

There is no significant difference between TMC scores for teachers classified as high inquiry-oriented and teachers classified as low inquiry-oriented for each of the rating methods: teacher, student, teacher's associate.

Hypothesis 2 (H_2):

For each of the three rating methods there are no significant differences between the students of teachers classified as high inquiry-oriented and teachers classified as low inquiry-oriented in their performance on the criterion measures: HIFAMS, TOSA, Science Mark, I. Q., TOUS-Ew, TOUS-Jw, SATS.

<u>Hypothesis 3</u> (H_3):

H_3a. When students are classified as desiring either a high inquiry-oriented science learning situation or a low inquiry-oriented science learning situation the two resultant groups show no significant differences in their performance on the criterion measures: HIFAMS, TOSA, Science Mark, TOUS-Ew, TOUS-Jw, SATS or STEP.

H_3b. When students are classified as desiring either a high inquiry-oriented science learning situation or a low inquiry-oriented science learning situation the two resultant groups will show no significant difference in their performance on the criterion measures: HIFAMS, TOSA, Science Mark, TOUS-Ew, TOUS-Jw, SATS, or STEP, when I.Q. is used as a covariate.

<u>Hypothesis 4</u> (H_4):

When students are classified as being either matched or not matched to their science learning situation there are no significant differences among the four resultant groups as indicated by their

a. Desired science learning situation, or D-scores

b. Actual science learning situation, or A-scores

c. Discrepancy scores, D - A.

<u>Hypothesis 5</u> (H_5):

When students are classified as being either matched or not matched to their science learning situation there are no significant differences among the four resultant groups when I.Q. is used as a covariate as indicated by their

a. Desired science learning situation, or D-scores

b. *Actual science learning situation, or A-scores*

c. *Discrepancy scores, D - A.*

Hypothesis 6 (H_6):

When students are classified as being either matched or not matched to their science learning situation there are no significant differences among the four resultant groups in their performance on the following criterion measures: HIFAMS, I.Q., SATS, Science Mark, STEP, TOSA, TOUS-Ew, TOUS-Jw.

Hypothesis 7 (H_7):

When students are classified as being either matched or not matched to their science learning situation there are no significant differences among the four resultant groups in their performance on the following criterion measures: HIFAMS, SATS, Science Mark, STEP, TOSA, TOUS-Ew and TOUS-Jw, when I.Q. is used as a covariate.

Limitations

1. *The measuring instruments are not, in all cases, designed to do exactly what is desired. Unfortunately a limited number of instruments are available for this type of study. Part of this study involves their construction.*

2. *Administration of the tests was left up to the teacher and hence is an uncontrolled variable. This situation is of considerable concern in obtaining valid scores from a teacher's associate on the SLSI-TA instrument. The assumption is made that the questions were answered independently, but since the*

only contact made with this associate was by a letter of explanation biases may produce inaccurate results.

3. The degree to which inquiry-orientedness is actually measured in the study classrooms is limited by two factors: the items chosen to describe inquiry-orientedness on the SLSI instruments and the pencil and paper method of measurement.

4. Intelligence test (I.Q.) scores are those reported by the teachers and are from either the Lorge-Thorndike or Otis Quick Scoring Mental Ability Tests. These two scores are used synonymously although their highest reported correlation is 0.85 (Lorge and Thorndike, 1957, p. 13). The utilization of these scores as synonymous is considered reasonable when the following variables are considered: I.Q. scores do not constitute a major aspect of the present study, control over testing conditions for ascertaining I.Q. scores parallel those for the present study, how current the reported I.Q. scores are may be more important than their correlation.

5. Measurement of student proficiency on his science nine course was not done with a standard exam but by teacher estimate. Although the comparability of these marks can be questioned this procedure is considered realistic since schools in Alberta are accredited and the same methodology is used by the Department of Education to ascertain all final student marks.

Delimitations

1. In the present study all treatment groups are ranked by degree of inquiry-orientedness. These groups are divided into thirds and subsequent statistical tests include only the top and bottom groups. No findings are reported for the middle group.
2. The findings will be applicable only to grade nine students in the Province of Alberta and resultant test norms valid during the spring months of the school year.
3. Data were collected from a large number of classrooms which are described as the population of the study and provide population means and variances. However, only a sample of this total data was used for the final analysis, primarily for economy of processing.

Significance of the Study

Is inquiry-oriented instruction a key pedagogical approach in science education? Can the degree of inquiry-orientedness of a classroom be determined and related to any criterion measures? Do different groups, e.g. teachers, students and external evaluators, view a given teaching-learning situation equivalently? Do students vary in their desire for learning environments and, if they do, what is the effect of this desire on their achievements? In addition, how is their achievement affected by their being matched or not matched to their desired learning situation? What progress can be made into the realm of evaluation in the affective domain?

Educators at all levels require information which provides answers to these questions: the teacher in providing for the individual student, the administrator in organizing a school program, the evaluator or superintendent in assessing the performance of teachers, and the university instructor in providing a course for future teachers. In addition, the development and utilization of measuring instruments in areas other than the cognitive domain should increase the scope of testing programs by allowing evaluation of a much wider range of objectives.

The significance of this study is to be measured by the degree to which it provides answers to the above questions and, in addition, by the potential of its findings to guide further research.

CHAPTER II

REVIEW OF RELATED LITERATURE

The review of the literature will follow the model presented in Figure 2. The introductory section of this chapter has to do with the bases for inquiry-oriented instruction. Subsequently, methodologies for describing the learning environment in terms of the characteristics of inquiry-oriented instruction are reviewed. These two sections provide background for the predictor component of the model (Figure 2) used as representative of the present study. Literature indicating possible relationships between the predictor component, teaching mode characteristics, and student attributes is reviewed in the following section. A major theoretical basis, the Conceptual Level Matching Model, is considered next to emphasize the use of TMC scores as the predictor variable and then possible relationships between the Matching Model and Inquiry-Oriented Instruction are discussed. Sections relevant to student attributes in the cognitive and affective domain follow and finally the relevance of the curriculum as a predictor variable is considered.

Inquiry-Oriented Instruction

Characteristics of inquiry-oriented instruction were presented earlier (Appendix A) and selected aspects utilized as the basis for describing Teaching Mode Characteristics. Views and research on inquiry instruction can be identified from two major groups: psychologists and science educators. These two sources will be considered here.

Psychologists and Inquiry-Oriented Instruction

Probably the psychologist most frequently referred to in discussing learning theory is Piaget. Piaget's theory of three stages of development (Piaget, 1954) each with characteristic abilities and limitations is utilized to build curricula and guide research. Much of the current research seeks to identify skills and activities relative to each stage and transitions between them. Knowledge of these skills and stages could be important in indicating which, and to what degree, process skills (see Appendix B) can be more profitably utilized during the various phases of the child's development.

Bruner apparently parallels Piaget as indicated by his dictum "any subject can be taught effectively in some intellectually honest form to any child at any stage of development" (Bruner, 1962, p. 33). Bruner maintains that to teach the basic ideas of a subject to young children one must present the ideas in terms of concrete operations through which the child is capable of grasping the central concept, although he may not be able to formally express the concept in words. What is required, according to Bruner, is that the child be helped to pass progressively from concrete thinking to the utilization of more conceptually adequate modes of thought. The potential that the stage of concrete operations has for meaningful teaching leads Bruner to enthusiastic endorsement of inquiry-oriented or what he calls the discovery method of teaching. The increased relevancy of inquiry-oriented instruction becomes evident in Bruner's later work as he stresses the need for relevancy and hence "curriculum not as a subject but as an approach to learning and using knowledge" (Bruner, 1971, p. 20). Process skills seem necessary if the

individual is going to have the ability to bring all his resources to bear on something that matters to him now.

Although Bruner presents his ideas on discovery learning as being based on the ideas of Piaget, some writers (Labinowich, 1969) see significant differences between Piaget's theories and Bruner's interpretation of them. Bruner's statement that basic concepts can be taught effectively at any level reflects disagreement with Piaget as to the necessary and sufficient conditions in which children will acquire such concepts, and the mental processes which underlie them. This disagreement is illustrated in two other basic assumptions upon which Bruner bases much of his theory of discovery teaching. One is the premise "that intellectual activity anywhere is the same, whether at the frontier of knowledge or in a third grade classroom" (Bruner, 1962, p. 33). He assumes further that "discovery, whether by a schoolboy going it on his own or by a scientist cultivating the growing edge of his field, is in its essence a matter of rearranging or transforming evidence in such a way that one is able to go beyond the evidence so reassembled, to additional new insights" (Bruner, 1961, p. 22).

Bruner feels that a number of benefits are to be derived from the experience of learning through discovery. First, he maintains that intellectual potency is increased by leading the learner to organize what he is encountering in a manner which will enable him to discover regularity and relationships. He also states that "practice in discovering for oneself teaches one to acquire information in a way that makes that information more readily viable in problem solving" (Bruner,

1961, p. 26) and enables one to deal with problems and values of current concern (Bruner, 1971, pp. 20-21).

Ausubel disagrees with Bruner on this point and asserts that it is not the process of discovery that organizes learning effectively for later use but the careful organization of the curriculum planners. Ausubel states (1961, p. 21) ".... the unsophisticated scientific mind is only confused by the natural complexities of raw, unsystematized empirical data, and learns much more from schematic models and diagrams." Although Ausubel has presented considerable evidence to support his technique of using advance organizers to improve meaningful learning and retention, he has always compared advance-organizers technique with non-organizer technique. A direct comparison of Ausubel's advance organizer technique with utilizing process skills to teach science indicates no conflict; this aspect of inquiry instruction would be viewed as a method of operationalizing Ausubel's recommendations.

Ausubel agrees with Bruner that inquiry-oriented instruction has much to recommend it in terms of motivation but maintains that good expository teaching is capable of generating motivation just as well as discovery methods. A problem is that expository teaching is often of the rote learning type and is carried out without regard to how concepts take shape in the mind of the learner. Also, Ausubel does not appear to recognize two important aspects: 1) inquiry-oriented instruction can take place in the expository mode, and 2) different learners may desire different learning situations or a variety of methods of teacher presentation.

Ausubel maintains that the process of discovery cannot be taught. Friedlander (1965), to some degree, expresses a similar concern in

questioning whether all students have the intuitive flair for discovery learning. These concerns are real but again would apply when teachers fail to take into consideration the different levels of complexity in which inquiry or discovery learning can be used.

A further point of disagreement is on how well material will be remembered as a result of different instructional methodologies. Ausubel states that discovery learning will have no bearing on how well the material will be remembered but maintains ".... most of what anyone really knows consists of insights discovered by others which have been communicated to him in a meaningful fashion" (Ausubel, 1961, p. 26). The present study is based on the idea that a variety of science learning situations are required if material is to be meaningful to the total population of students; these ideas do not appear contradictory.

Disagreement exists between the present study and Ausubel's definition of inquiry. He contrasts discovery or inquiry learning with reception learning which he describes as a situation where the entire content of what is to be learned is presented in final form and requires only internalizing; inquiry-oriented instruction does not preclude this situation but may provide a more meaningful way of approaching it. Also basic to Ausubel's position is his assertion that the main objectives of education are, first, the long term acquisition and retention of stable, organized, generalizable knowledge, and second, growth in the ability to use this knowledge in solutions of particular problems.

Ausubel's assumption that the student's main goal is to acquire subject matter is not valid in the case of science, where process is equally important. Ausubel does not completely ignore the problem and

in fact, supports the use of inquiry techniques in teaching the process of science. Since he does not deal with this question in depth, he has left the misinterpretation that he is entirely opposed to inductive techniques.

Gagne is another psychologist whose work has had considerable impact on the development of inquiry-oriented curricula. He sees the central problem of science education as being the development of a method of instruction which will teach students the discovery approach of science. Central to this method of instruction is the development of students' skill in the processes of science. This first involves, according to Gagne, the identification of the terminal capability, that is, what the student will be able to do after he has learned a process skill. Specifically, Gagne feels that the student should regard each newly encountered phenomenon as a challenge for thinking. He (Gagne, 1963, p. 154) states:

> Such thinking begins with a careful set of systematic observations, proceeds to design the measurements required, clearly distinguishes between what is observed and what is inferred, invents interpretations which are under ideal circumstances brilliant leaps, but always testable, and draws reasonable conclusions.

Gagne also states that we must identify the instructional conditions which will bring about this change in the student's capability. He feels that while practice in inquiry is certainly valuable, it is not the whole story, and that there is a danger that practising inquiring too soon and without enough background can restrict the development of independent thinking. Pre-requisite to the practice of inquiry, Gagne maintains, is the possession of an organized body of knowledge, the

ability to apply general principles to specific situations, and the ability to evaluate an idea.

Gagne's main association with the inquiry curriculum is through AAAS (American Association for the Advancement of Science) elementary school program, "Science - A Process Approach".

The present study utilizes aspects of each of the views presented above. Piaget and Bruner indicate different students learn in different manners at different times. It seems logical to conclude different instructional methodologies and levels of presentation are desirable and students should be exposed to a learning situation compatible with their needs or desires: namely, matched to their science learning situation. Ausubel supports this idea to some degree in indicating organization is required to facilitate optimum learning although his limited definition of inquiry precludes it for major consideration. Gagne's ideas of teaching process skills and identifying optimum science learning situations are central to the present study.

Science Educators and Inquiry-Oriented Instruction

Psychologists emphasize the nature of learning as a starting point for developing a science program whereas the science educators show appropriate concern for the structure of scientific disciplines. Schwab (1966, pp. 32-37) illustrates this concern when he identifies four groups of factors which he considers basic to curriculum development: 1) subject matter - the character and state of the discipline, 2) milieu group - the needs, demands and conditions which social structures impose upon their members, 3) learner group - concerns related to the character-

istics of the individual, and 4) teacher group - concerns related to the type of person and his training. Schwab indicates the inadequacy of subject content patterned curricula as they relate to these factors. He proposes an inquiry-oriented curriculum as more sufficient and desirable for teaching students the essence of science.

Schwab contends an inquiry-oriented curriculum is necessary because of two major problems: 1) the tremendous increase in volume of scientific information, and 2) the change in the nature of science from a relatively static body of information about the nature of the world, to an active process of inquiring into the nature of the world. Novak (1964, p. 26) supports this two-fold argument for an inquiry-oriented curriculum when he says, "Not only is there an exponential growth in information which tends to be overwhelming, but there is a dynamics in science..."

Concern is expressed for the fact that while science as a discipline has changed, and now involves more emphasis on the dynamics, science teaching has failed to reflect that change. Schwab (1966, p. 21) suggests that the change in the science discipline has come about as it has taken on a more significant role in the economics and politics of our society and become "the foundation of national power and productivity" (1966, p. 21). The resulting intensification of scientific work has increased the rapidity of revision of scientific knowledge to a point where the average revisionary cycle lasts about 15 years, (Schwab, 1966, p. 18) much less than the lifetime of a scientist.

Science education must take account of these changes and find a way to cope with the problems they create. Hurd (1964, p. 7) says,

> To escape the threat of obsolescence, education in the sciences must be based upon the kind of information that has survival value and upon strategies of inquiry that facilitate the adaptation of knowledge to new demands.

Novak (1964, p. 26) agrees, "The problem in science education today is to avoid teaching science as a rhetoric of conclusions and to teach it as scientific inquiry". These ideas appear to parallel Bruner's ideas to a significant degree. Additional agreement comes from Hurd (1964, p. 7) in his proposal that science education must be oriented towards lifelong learning, rational and independent thinking and acquisition of productive knowledge. He (1964, p. 7) contends that "inquiry skills will provide the learner with tools for independent learning" and that the use of conceptual structures as the basis for inquiry will supply an increased stability. In short it is proposed that an inquiry-based curriculum more nearly reflects the nature of the science discipline and would thus be more valid as a medium to get across this nature. In addition such a curriculum should thus prepare a more informed public and prepare leaders who must make decisions regarding science research and development.

These ideas provide the basis for science education from the science educators' point of view and a reason for including inquiry-orientedness as a basis for Teaching Mode Characteristics in the present study.

Nay (Nay and Associates, 1971, pp. 197-201) describes a strategy by which the objectives of science education may be operationalized: "To enhance a student's comprehension of how scientists work and scientific knowledge evolves, a science curriculum must be provided in which

selected concepts and the associated processes of inquiry are integrated" (Nay and Associates, 1971, p. 197). Nay (1971, p. 197) indicates that in the implementation of this integration there are "potentially many process-approaches to teaching science" depending on the "processes" involved and the use made of them.

Nay's process approach is based on and defined in terms of an organized "Inventory of Processes in Scientific Inquiry" (Appendix B). In this system it is desired that the curriculum "reflect the multi-dimensionality of science (Nay and Associates, 1971, p. 198)". He explains further (1971, p. 198):

> That is, the science curriculum should include knowledge (or the product of inquiry), the processes involved in obtaining this knowledge, the attributes displayed by scientists engaged in inquiry, the history and philosophy of science, and finally the social consequences of scientific discoveries.

The concept of a process approach is not new since it is inherent in Dewey's five-step "scientific method" consisting of defining a problem, forming an hypothesis, planning a test of the hypothesis, gathering data and forming conclusions. This formalism has, for decades, been "quoted in the introduction of almost every science textbook (but virtually ignored in subsequent chapters!)" (Nay and Associates, 1971, p. 198). Modification of Dewey's model have appeared (Schwab, 1966; Welch, 1966; Brown, 1968) but an instructional program based on them was neither developed nor implemented until relatively recently: that is, a curriculum which has as a basic premise the idea that the "behavior of scientists can be analyzed into simpler activities, and that these can be arranged in a hierarchy of complexity for purposes of instruction" (Nay and Associates, 1971, p. 199).

Thus the "behavior of scientists" becomes an instructional model. That is, it is assumed that the activities of the scientists may be learned by students, providing appropriate instruction is involved. Nay's approach is somewhat unique in that it is described by an organized Inventory of Processes in Scientific Inquiry based on the study of reality in science, including scientists. Although many "Science teachers already include the process dimension to a greater or less degree", (Nay and Associates, 1971, p. 200) a consistent and systematic approach may be lacking. The Inventory, as a model for instruction, aims to provide the structure required for a consistent and systematic approach to teaching science. As well, students "generally enjoy the practical work involved in an investigation" (Nay and Associates, 1971, p. 200) and impetus to learning should certainly be provided by not only basing a course on student activity but teaching the student, in detail, how to carry out the desired activities or, in other words, develop expertise in some of the important steps in scientific methodology.

Process skills referred to in the present study are those inventoried by Nay and Associates ("An Inventory of Processess in Scientific Inquiry" in Appendix B) although it is acknowledged that most new science programs are coming out with a list of "process skills". In addition, since inquiry-orientedness permeates the literature to a high degree a methodology of quantifying it and relating this quantification to student attributes seems desirable and needed. These are major objectives of the present study.

Research on Inquiry-Oriented Instruction

Is there a best way to teach? Does inquiry-oriented instruction

produce a predictable or unique set of student attributes? Several researchers have addressed themselves to these problems.

Goldman and Goldman (1974, pp. 53-58) present a problem solving model in which the individual performs activities similar to the process skills utilized by Nay and others. They produce the model to facilitate "change from a teacher-centered to a student-centered class" (Goldman and Goldman, 1974, p. 53). As well, they claim the "skills learned in following this problem solving model are those which will be useful long after memory of details of the course content have dimmed" (Goldman and Goldman, 1974, p. 58). Of significance in this article is the proposal of a methodology of teaching a complete and integrated set of processes such as Nay and Associates (1971, pp. 197-201) have done.

Piaget and Bruner emphasize the importance of each student being exposed to an appropriate learning situation compatible with his current stage of development. Lewin (1974, pp. 54-56) reiterates this position and includes process skills as well as cognitive structures in the learning hierarchy and emphasizes their importance in learning how to learn. With respect to teaching children how to learn Thelen (1960, p. 160) expresses concern with evaluation and its misuse in achieving this education goal. These variables of providing an appropriate learning situation, teaching inquiry skills and the evaluation of cognitive and affective outcomes should be considered in research on inquiry-oriented instruction and are the major components of the present study.

Suchman (1962) devised an experiment to provide answers to the questions: 1) Does inquiry training produce measurable changes in the inquiry process when it is conducted in the ordinary classroom setting?

2) Does the acquisition of information and growth of science concepts through inquiry training compare favorably with learning that is programmed and controlled more directly by the teacher?

Twelve male teachers of above average interest in science received an eight week workshop in inquiry which Suchman (1962, p. 4) defined as, "... a form of human behavior in which a person acts to increase the meaningfulness of his knowledge and experience". Two classes of sixth grade students, one inquiry and one control, matched in ability, were organized in each school; in some cases the same teacher taught both classes. Both groups were shown a problem episode film but in the control group the follow-up was by relevant physics experiments, lectures and reading assignments. The experimental group received inquiry training and then individuals were permitted to ask questions about the film that could be answered by "yes" or "no". A critique followed the questioning session. Students from the two treatment groups were compared on a standardized cognitive test, a test of identification of underlying principles and a test on the frequency and type of question asked.

The results indicated no differences on the cognitive tests, the inquiry approach took more time and the experimental group asked more questions and of an analytical nature.

Suchman's research ignores matching of students and desired science learning situation, has a very limited operational component of inquiry and the evaluation instruments leave much to be desired. The present study attempts to incorporate and expand all these areas.

Ivany (1965) conducted a similar set of experiments at the grade eight level to ascertain which of two modes of instruction (hypothetical and expositional) elicited a greater amount of inquiry activity and better cognitive results. He found no significant differences in cognitive outcomes but, not surprisingly, the group classified as nonexpository showed more inquiry-orientedness.

As with Suchman, Ivany utilizes such a limited definition of inquiry his results can hardly be used to compare the two hypothetical modes: expository and inquiry. Expansion and description of the characteristics of a science learning situation as it actually exists, and not as set up artificially, are aspects of the present study.

Scott (1966), using a Suchman type experimental model, employed a "styles of categorization test" as his measure of differences produced between the experimental and the control groups. He (Scott, 1966, p. 143) had two questions to be answered: 1) Would an inquiry program have a continued effect on children's behavior after the novelty of the situation had passed? 2) Would the verbal behavior changes in the inquiry program children in a three-year study be traceable to the elements of the strategy emphasized during the program?

Scott started the program with 25 grade 5 students in 1962 and continued using the inquiry approach through June, 1965. The students were given about 100 minutes of inquiry training per week throughout the year. They were tested with the Siegel Cognitive Styles Test in September, 1962, June, 1964, and June, 1965. A group of children who had not experienced the Inquiry Program were matched with the experimental group at each testing period.

The results were as follows (Scott, 1966, p. 153):

> Inquiry strategy appears to have had a continuing effect on the verbal behavior of this group of children over the three-year testing period. The children exposed changed in several different ways: verbal fluency and flexibility were increased; attention to detail became more accurate; inferences as to invisible attributes showed a strong trend away from the emotional and locational responses, and toward the inherent classification attributes and each of these changes can be reasonably traced to a specific emphasis of the inquiry strategy used in this program.

A large number of other studies paralleling that done by Suchman have been conducted: Brown (1967), Renne (1970), Butts and Jones (1966). They all have in common several experimental weaknesses and outcomes. Most use definitions of inquiry-orientedness which are limited and/or unrealistic. Few significant differences were reported on any of the dependent variables being tested. Finally, none took into consideration either student preference or a typical style of teaching.

Research on discovery inquiry learning by psychologists expresses similar concerns: lack of accepted definitions of discovery or inquiry learning, few significant differences in hypothesis testing, validity of experimental design, lack of consideration of individual differences, and non-typical classroom situations (Cronbach, 1966; Glaser, 1966; Wittrock, 1966; Hermann, 1969).

The present study utilizes a comprehensive list of inquiry-oriented teaching characteristics gleaned from the literature, views teachers in a natural situation and classified them by the degree to which they utilize the specified characteristics. It does not attempt to prove there is a best way to teach but is comparing the ongoing science learning situations with respect to desirability as perceived by

the client, the student, and the results which can be associated with matching or not matching students with their desired science learning situation. The results of this are checked in terms of behavior in affective and cognitive domains.

Describing The Science Learning Situation

For purposes of the present study, the teaching mode characteristics have been defined in terms of characteristics of inquiry teaching and learning. Specification of the latter is given in Appendix A and its importance in science teaching discussed in the previous section. It is now necessary to consider the reliability of the source of information for identifying the actual teaching-learning situation in a classroom. Several sources are available: the teachers themselves, their students, and external evaluators (e.g. peers, administrators, evaluation experts).

Peer Evaluation of the Learning Situation

Elliot in her article "Peer Evaluation For Teachers? Why Not?" (1974) expresses doubts about administrators making good evaluators but has "tremendous faith in the good 'horse sense' of teachers" and their ability to choose those most qualified to evaluate (Elliot, 1974, p. 727). Elliot further suggests a plan for implementing evaluation by peers (1974, p. 727):

> Teachers within the school should submit a list of names to the principal from which to choose a team of evaluators. The responsibility of this committee is not only to evaluate teachers, but administrators as well.

It seems feasible that through daily informal discussions between teaching companions and the interaction of different teachers with each others' students a considerable amount of mutual personal information will be obtained. The degree to which Elliot's opinions regarding the teacher's peer group as a reliable and valid source for describing their companion's teaching-learning situation are accurate will be partially investigated in the present study. One source of information on each science learning situation is a teacher's peer.

Teacher Evaluation of the Learning Situation

McNeil and Popham (1973, pp. 231-232) report on teacher self-ratings and related studies. Major problems involved in utilizing teachers to evaluate themselves are centered on the lack of training in focusing on relevant aspects of their work. Also, they need others "to keep them honest" (McNeil and Popham, 1973, p. 232).

The writer does not endorse self-rating schemes since they do not take into consideration individual aspirations. In education, one group of teachers in trying to attain perfection may underrate themselves, and others, lacking a desirable model of instruction, may be very satisfied with their performance and hence overrate themselves.

Results of the present study will provide the teachers with a self-rating instrument and a tested model against which to compare themselves.

Student Evaluation of the Learning Situation

Somewhat in apparent contradiction to Elliot's views appears to be an approach which is increasingly supported over other descriptive

methods such as that involving an external evaluator. Walberg utilized student perception of the learning environment successfully in the series of studies described in the following section. This orientation is based on the premise that the stimulus from the teacher affects learning only to the extent that it registers with the learner. Considerable research (Elam, 1974a; Purchit et al, 1970; Thompson, 1965; Costin and Menges, 1971; Walberg and Anderson, 1968) supports this view. Elam (1974, p. 23) reports that "the best source of information about the public school in their communities is the students themselves". This information comes from the 1973 Gallup poll of public attitudes toward the public schools and was compiled and summarized from a five year (1969-73) survey by George Gallup. Two important ideas for the present study are intimated in the survey: 1) the idea of the student as an important source of information and, 2) the necessity of instruments to obtain information from students, particularly in the area of attitudes.

Thompson (1974, pp. 25-27) considers criteria used by students in rating their instructors and the stability of these criteria and ratings. Major studies (Purchit, 1970, p. 3) support the use of students to obtain consistent ratings of instructors. In fact, "A teacher well rated five years ago will likely receive the same rating from students this year" (Thompson, 1974, p. 26).

With respect to specific criteria one of the reviewed studies showed student ratings of instructors were not significantly related to individual factors such as sex, year in school, grade point average, expected course grade, hours spent in studying and absenteeism (Thompson, 1974, p. 21). In this study (Rayder, 1970) the statistical analysis was

based on data collected on 87 instructors from questionnaires filled in by 4285 students. Each student filled in a questionnaire rating his instructor on three continua of characteristics (Rayder, 1970, p. 5). Thompson reviewed additional studies (1974, p. 26) and similarly found no relationships between the above stated student variables and ratings of their instructors.

The lack of significant correlations between the personal student characteristics which could create biases and ratings of their instructors plus the stability of their ratings are indicative of the validity (content, predictive and concurrent) of their ratings.

Costin and Menges (1971) in a study similar to those reviewed by Thompson develop support for aspects of reliability, validity and usefulness of student ratings. Students were polled on characteristics they would use to describe good teachers; the traits they selected in their descriptions were used to ascertain the validity (content, construct) of their judgements. Costin and Menges (1971, p. 534) indicate the results of their study supports the validity of utilization of students for judging teachers. In support of this statement are four of the characteristics most frequently mentioned by students to identify good teachers: 1) knowledge of subject matter, 2) well planned and organized lectures, 3) enthusiastic and lively, and 4) student-oriented, friendly and willing to help. Costin and Menges (1971, p. 535) maintain student acceptance of these characteristics are positive indicators of validity, and that this validity (concurrent) is further increased as a result of the students rejecting the following as criteria for effective

teaching: 1) entertainment, 2) student's gain in knowledge and 3) achievement.

Walberg (1969, p. 444) rejects many "behavioral scales and observation schedules" used for describing different classroom situations for the following reasons: 1) the problem of training staff sufficiently to produce objective, reliable results; 2) travel costs to scattered locations throughout the country; 3) the unnatural, sometimes threatening nature of a strange observer in the classroom; and 4) the predictive validity of the measures. With respect to validity of the measures Walberg points out that "few studies have reported significant predictions of learning from them (Medley and Mitzel, 1963), and these few have failed to account for substantial variance, say 20% in the learning criteria (1969, p. 444)".

In the present study the students are considered as a major source of information about their science learning situation. The student is the only one who can tell what he desires and what he perceives is actually happening.

Problems Associated With Observing The Learning Situation

Rosenshine and Furst (1973, pp. 122-183) discuss the use of direct observation to study teaching. They describe the research on teaching in natural settings as chaotic and unorganized (1973, p. 122) with major problems in all associated areas such as distinguishing instrumentation type, differences in format, differences in purposes, functional value of instruments and not enough reviews of relevant research. One of the major problems associated with classifying an

observational instrument is in knowing the uses to which the instrument has been put (Rosenshine and Furst, 1973, p. 159). It is further suggested that variables used on instruments be derived from experimentation rather than inspiration (Rosenshine and Furst, 1973, p. 166). An important aspect of "reliability" which is hard to define with respect to teacher observation instruments is the different frames of reference of different publics using a given instrument (Rosenshine and Furst, 1973, p. 168). Rosenshine and Furst (1973, p. 175) suggest that "studying teaching in natural settings is unproductive because the settings are not functional for the desired outcomes".

The present study takes the major problems raised by Rosenshine and Furst into consideration in developing the Science Learning Situation Inventory (SLSI): a detailed base for the instrument is described, the function and purposes are given, the instrument is designed for a natural setting in teaching mode characteristics used and in method of application. The variables utilized result from a major pilot study, namely experimentation, and a comparison of its use by various raters is part of the experimental design.

Summary

On the basis of the literature cited, it seems that two groups, the students, and the teacher's peer group may have aspects of reliability and validity as sources for describing science learning situations. These two groups as well as teacher self-evaluation will be utilized and compared in the present study.

Relationships Between Teaching Mode Characteristics And Student Attributes

The major thrust of this study is to relate a set of teaching mode characteristics (TMC) to student attributes in the cognitive and affective domains. The assumption is made that these teaching mode characteristics are not just correlated with student attributes but are in fact in a cause and effect relationship with them, with these attributes being dependent variables. Several recent articles focus on this relationship.

A study reported by Emmer et al (1974, pp. 700-704) indicates that pupil participation in a teacher's lesson affects subsequent preference by that teacher for expository or discovery teaching styles. Teachers will use the type of instruction that they find elicits the most student participation. Exactly what some of the characteristics of the teaching styles are and the results of students on given instruments are left to be identified. Emmer's study suggests (1974, pp. 702-704) an aspect relevant to the present study which needs investigation: do changes in teacher style result in changes in pupil behavior?

In an assessment of teacher influence on students' basic values and behavior at various grade levels, Harrison and Westerman (1973, p. 228) report that 74.3% of the junior high school students are significantly influenced by their teachers. In what areas they are influenced is a major question and exactly what influences them is a further item of concern. However, the relatively high percentage of students reporting they are being influenced also report that teachers are rated as

only at the 4.4 percent level with respect to groups with the greatest impact on their basic values and behaviors; this makes the identification of those factors causing the influence very significant. Also, when junior high school and senior high school students are compared, the junior high school students report a much greater degree of influence by teachers (Harrison and Westerman, 1973, p. 228). Hence, it appears desirable to test junior high school students to ascertain factors that do influence them. In addition, "consistent and sizeable decline in the negative influence of teachers from the junior high to the university level" was reported by Harrison and Westerman (1973, p. 230). Thus a greater opportunity may exist for identifying characteristics causing teaching influence in groups of junior high students. Another relevant point made (Harrison and Westerman, 1973, p. 230) is that most students never told their teacher that they were influenced by them. That is, the needed feedback as indicated in Emmer's studies (1974, pp. 700-704) is frequently absent. Instruments to obtain this feedback appear desirable and should result from the present study.

Attempting to predict or differentiate student attributes or characteristics as a result of their descriptions of the learning situation is the basis of a series of studies evaluating, in part, Harvard Projects Physics (Walberg and Ahlgren, 1970; Walberg, 1970; Walberg, 1969a, b; Walberg and Anderson, 1968; Walberg and Welch, 1967). The theoretical framework for this series of articles comes from the Getzels-Thelen theory of the classroom as a social system (Getzels and Thelen, 1960).

In this series of studies Walberg, Ahlgren, Anderson and Welch showed that "measures of student perception of classroom environment obtained at midyear predict gains in cognitive, affective, and behavioral learning criteria during the school year" (Walberg, 1970, p. 153). These predictions remained when the effect of such covariants as I.Q., initial differences in achievement and interest in the subject were removed from the student characteristics measurements.

To identify student characteristics, Walberg (1969b) administered a battery of tests measuring cognitive, affective and behavioral attributes. Among these criterion measures were the Physics Achievement Test, the Welch Science Process Inventory, the Pupil Activity Inventory and Test On Understanding Science. The objective was to inter-correlate the student characteristics of classes (Walberg and Ahlgren, 1970). The respondent was asked to indicate on a 4-point agree-disagree scale how well each statement describes his class. Items were of the type, "The students enjoy their class work." and, "Each student knows the goals of this course." (Walberg, 1969b, p. 444). Sets of seven similar item responses were averaged to give 14 separate scores. To estimate the environment for a class the scores of individual students within the class were averaged (Walberg and Ahlgren, 1970, p. 154).

In an initial study (Walberg and Anderson, 1968) 76 classes throughout the United States were used; in a subsequent study 75 teachers and 144 classes were used (Walberg, 1969b; Walberg and Ahlgren, 1970). The data were collected using a randomized data-collection system which resulted in about 85 out of 1700 students writing any given combination of pre, mid, and post-tests. Gain scores were calculated from each of

the criterial variables which were then correlated with each of the measures of classroom climate.

The results indicated 32 statistically significant correlations ($p < 0.05$) between measured perceptions of classroom climate and the adjusted learning variables. This amounts to four times the change expectancy (Walberg and Anderson, 1969, p. 416). Walberg (1969b, p. 445) found that he could predict all post-tests using the environment scales. Thus by putting together those environment characteristic scores which correlated significantly with post-test scores Walberg developed scales of predictors and criterion variables.

The outcomes of Walberg's studies, in particular, parallel and augment this study in their attempts to describe the classroom or teaching mode characteristics associated with student growth in both the affective and the cognitive domains. One additional feature of this study will be an attempt to investigate the individual within the classroom instead of the classroom itself. This additional research, as well as research at different grade levels is recommended by Walberg and Ahlgren, (Walberg, 1969b, p. 448; Walberg and Ahlgren, 1970, p. 166). Also, the statistics of the above described series of investigations make it probable and much instrumentation from these studies is usable to provide an individual teacher with pertinent information about his classroom situation. Most instruments utilized in the present study should be of value to the classroom teacher.

Matching Students and Learning Situations

Comparing the teacher and student with respect to their learning situations is representative of many projects and theories in education. The basic tenet is that the prime consideration for the teacher is to structure the learning situation to best match that desired by the student and that actually experienced by the student. In science this might be facilitated by providing different levels of inquiry-orientedness.

In addition to the discrepancy studies by Cheong and DeVault discussed in Chapter I, Hunt's conceptual level matching model is concerned with the matching of learning styles (or information processing styles of the student) and teaching methods (or information processing styles of the teachers). Hunt (1974, p. 264) states:

> Students differ in how they learn, or in their learning styles. For example, some learn better by listening to the teacher, some by discussions, and others by working on their own. To say that students differ in their learning styles does not mean that a student needs only one approach (exclusively), but that, generally speaking, he has one way of learning which for him is better than others.

Hunt identifies a wide variety of teaching methods (e.g. lectures, discussion, discovery) and suggests that grouping students by learning styles would enable teachers to use the teaching method most likely to work for the majority of students in the class. Thus the important variable used in student classification is the "way they learn" and grouping by these learning styles is a procedure which can be used to maximize the likelihood that teachers will meet the needs of the students (Hunt, 1974, p. 264).

Key characteristics have been associated with the different types of learning styles and matching environments. Hunt (1974) describes learning styles in terms of conceptual level (CL) which ranges from very low to low, to high. Although a person's development through the conceptual levels is viewed as continuous, Hunt states the process can best be described in stages: (A) immature, unsocialized, (B) dependent, conforming and (C) independent, self-reliant (Hunt, 1974, pp. 208-209). "A person's conceptual level also indicates his capacity to process information effectively" (Hunt, 1974, p. 212). Hunt lists the characteristics of environmental structure (1974, pp. 213-214). This environment change from high to low structure is exemplified by Hunt as a change from teacher-centered to student-centered. "A person and his environment are developmentally matched if the combination produces progression" (Hunt, 1974, p. 210).

Hunt cites experimental evidence for his conceptual level matching model (1974, pp. 219-221), the main study consisting of taking an equal number of "low and high CL students, matched on ability", (1974, p. 218) and assigning them to each of two instructional methods; discovery (low structure) and lecture (high structure). The numbers of students and the age level are not reported.

The content of the presentation consisted of a specially designed set of visual materials aimed at acquainting the student with the Picasso painting "Guernica". Students in both conditions were shown the same pictorial materials: a slide containing the entire picture and a series of component parts of the picture on separate slides. Students in the lecture method heard a short explanation of the meaning of each component

slide, while students in the discovery method viewed each slide for a comparable length of time but were instructed to work out for themselves what the picture meant. Afterward, students were asked to give their own ideas of the central meaning of the picture and of how the parts fitted together into this meaning (subjective integration).

"Results indicated that the low CL students performed significantly better ($p < 0.05$) with high structure (lecture) than with low structure (discovery)" (Hunt, 1974, p. 218). High CL students, although they prefer low structure may perform equally as well in other learning situations.

Hunt emphasizes that the matching model does not specify how to implement person-environment matching but only "specifies the nature of the match" (1974, p. 222). The present study will attempt to get at some of the critical variables in matching by first identifying the TMC associated with different learning situations and subsequently the student attributes resulting from matching or not matching students with their desired learning situations.

The Matching Model and Inquiry-Oriented Instruction

Using Hunt's matching model (1974, p. 221-222) "student-centered" or "discovery learning" are characteristics given for a low structure environment which is meant to be matched with a high student conceptual level. For purposes of the present study high inquiry-orientedness is similar to Hunt's low structure environment. However, one classroom need not be considered synonymous with one mode of structure. For example, considering one major aspect of inquiry, the process-skills,

(Nay and Associates, 1971, pp. 197-201), it is maintained that a heterogeneous classroom may be matched by a heterogeneous teaching style wherein one teacher can react discriminantly to individual students. That is, one teacher, using several instructional modes and strategies should be able to adapt to the degree of structure desired by a given student.

Again, specifically considering utilization of the process skills (Appendix B), in a particular lesson the gamut is spanned from providing the particular process for the student to follow to having him actually identify and perform the indicated operations himself. This continuum exists for each of the processes relevant to the given lesson. Also, a variety of instructional procedures can be used in presenting the processes ranging from lecture to movie to guessing. The teacher can provide or withhold information on a given process to create the amount of structure he deems desirable for each student, not necessarily a whole class. In essence then, the amount of structure placed on the situation is influenced by the degree to which the teacher provides the student with information on the processes, that is, the amount of guidance given.

Even when the class is heterogeneous so far as cognitive style is concerned, a particular lesson can be structured so each student has available optional amounts of materials or input devices with respect to a given process. For example, one student may desire the freedom to design his own experiment whereas another may want to choose from several provided and still another may wish to be given a specific set of instructions to follow. Similarly, one student may wish to read about and see samples of actual data which has been collected while another might

wish to watch a movie on scientists gathering information relevant to his problem and still a third may want to collect his own. Several degrees of structure are open to the teacher and the learner.

Thus a teacher utilizing process skills within a wide variety of strategies should be able to structure a given environment in the modes indicated by Hunt to suit even a heterogeneous class. This process approach is unique in the aspect in that it can simultaneously cater to the range of students from very low conceptual level to high conceptual level. In the present study the degree to which students experience utilization of the science process skills is one of the indicators of inquiry-orientedness. Biggs comments on the complexities involved in adjusting for cognitive style as follows (1972, pp. 97-98).

> When we consider cognitive styles, then, we are forced to reconsider our notions of "ability". Ability no longer comes out as a single unitary trait that can be measured quantitatively. We think rather of a multiple complex of styles and aptitudes that interact with each other in different ways according to the immediate task and how it is presented. We cease thinking in terms of the "one best method" of teaching a given subject. We may begin looking around for different methods of evaluation. Most importantly, we begin to think of Johnny not as a plodder (with a low IQ) but as a complexly determined individual whose particular mix of information processing styles doesn't happen to suit the tasks we have been putting in front of him so far.
>
> By breaking down thinking and learning into stages, from precoding to retrieval and output, the teacher might begin to get some clues as to the difficulties Johnny is having in handling the task at different stages of his processing cycle. At the present stage of our knowledge, this kind of person-job analysis will be intuitive rather than exact, and perhaps better suited to informal than to formal adaptations of individual differences. However, with more research into these interactions, and more accurate measures of the processing stages, perhaps education will move towards the highly individualized process that many educators believe it should be.

Individualizing instruction, aiding the student in becoming more self-sufficient and yet creating optimal conditions for a given student for a given learning objective demands detailed environment control. Interdependent training (Shroder et al, 1967, p. 49) refers to providing the learner with an environment that can provide information as feedback as a consequence of his own questions and is illustrated by considering a teacher introducing the topic of density and specific gravity to a class. The topic might be introduced by showing a class that two objects which are of identical size may, when placed on an equal arm balance prove to be very different in weight. Similarly two objects of different sizes can be shown to have identical weights. From this series of observations the subsequent learning environments may be structured in more or less detail to suit students of varying conceptual level complexity. For instance, one student may wish to proceed to design and carry out investigations in an attempt to identify the important properties of matter associated with the observed phenomenon. A knowledge of the processes and their use will allow him to do this as they constitute a strategy of problem solving. This would be a very unstructured situation in Hunt's terms.

A complete range of other attacks on the problem, all based on a knowledge of the processes can be made available to the students. For example, at the other end of the cognitive style continuum a student might desire to be provided with detailed information on each of the processes and hence be led through a series of simple investigations in a highly structured manner.

The model of different conceptual levels also provides a warning

for a rather common practice of providing all students with the same structure in all process-oriented investigations such as "unipacs" or other similar instructional materials. A discussion of variables and problems associated with individualized instruction packages is contained in a colloquium on that topic by Roberts (1971).

Allowing students to attack a given problem in a manner of their choice frees the teacher for considerable one-to-one interaction and excessive guidance where and with whom it is required. This freedom is one redeeming feature of the above mentioned "unipac" approach in that different structure might be provided by extensive teacher-student interaction in some cases. By basing the environmental structure on the degree to which information is given on the processes it is hypothesized that the science teacher can create a situation inherently adaptable to the many cognitive styles found in most classes. That is, matching students and science learning situations may not necessarily mean matching students with different teachers but with teachers that can identify and cater to an individual student's desire for a particular science learning situation.

The design of the present study takes into consideration the individual student within the classroom and thus the idea of teacher flexibility to deal with a heterogeneous group can be ascertained.

Affective Domain

The affective domain encompasses many aspects including attitudes which are desirable both with respect to school and to science, attitudes actually held with respect to school and science, attitudes

scientists have and attitudes a scientist should have. Some work has been done on models for assessment in the affective domain but research on attitude development is limited.

Klopfer (1971) has identified at least six attitude interest-based objectives for science education. These are: manifestation of favorable attitudes toward science and scientists, acceptance of scientific inquiry as a way of thought, adoption of "scientific attitudes", enjoyment of science learning experiences, development of interests in science and science related activities and development of interest in pursuing a career in science.

Nay and Crocker (1970, pp. 61-62) have developed an inventory of 65 affective attributes which scientists are generally expected to demonstrate in their work. In a procedure similar to developing the process inventory (Nay and Associates, 1970), Nay and Crocker (1970) began by identifying affective attributes exhibited by scientists in their professional activities. Following this each affective attribute was characterized or defined in terms of the specific behaviors manifested by scientists in their work and in relationships with their peers. They identify five major areas, each with several subheadings. The five main areas are: Interest, Operational Adjustments, Attitudes or Intellectual Adjustments, Appreciations and Values and/or Beliefs. Furthermore, they provided a method of dealing with the affective domain in science teaching by deriving behavioral objectives from a determination of the affective behavior of scientists at work. Kozlow (1973, p. 6) extended the model by defining three dimensions of affective behavior: cognitive (knowledge), intent and action. The <u>cognitive</u>

dimension represents the students understanding of the role of the affective attributes in the professional activities of scientists. The intent dimension refers to the affective behavior a student claims he or she will exhibit in a specified science situation. The action dimension refers to the actual affective behavior displayed by a student in a specified situation.

Kozlow and Nay (Kozlow, 1973; Kozlow and Nay, 1976) used the inventory of Nay and Crocker (1970) and its further development by Kozlow (1973) as a basis for constructing a multiple-choice Test on Scientific Attitude in which the cognitive and intent dimensions of several attitudinal behaviors of students were measured (Kozlow and Nay, 1976). This test was used in a study to assess the congruence of the classification of the test items into attitude categories on the basis of the rationale developed by Nay, Crocker and Kozlow with the classification that was derived from a factor analysis of test results. A high level of congruence was achieved, despite weaknesses in the test which became evident in due course. Relevant statistical data gathered in this study will be presented in Chapter III.

These developmental procedures used by Nay, Crocker and Kozlow illustrate a technique for considering the much neglected affective domain, a domain of prime importance in the present study.

In addition, Kozlow and Nay (1976, p. 151) summarize the dimension of test format basic to their test development and to the present study.

> Starting with the work of Thurstone, several modes or strategies have been developed for measuring attitudes. The major ones are the Thurstone scales [Thurstone, 1967a, 1967b;

> Torgerson, 1958, pp. 18-20], Likert scales [Likert, 1967, p. 21], and semantic differential [Osgood, 1957, p. 22]. Other methods used in attitude measurement are questionnaires, interview schedules, sentence completion, picture-interpretation, word association, and error-choice [Oppenheim, 1956; Shaw and Wright, 1967, pp. 23-24]. Each of the above methods has drawbacks and limitations. The Thurstone scales are very appealing to use in measuring attitudes, since Thurstone developed a sound theoretical and mathematical foundation to support the analytical procedures which are used in the calculation of the scale values. However, in the construction of his scale, Thurstone assumed a unidimensional attitude object. Therefore, a large number of scales would be required to identify all of the dimensions of the affective domain in science education. Since a considerable amount of work is required on the part of the respondents who provide the data from which the scale is to be determined, the construction of a large number of scales may not be a practical undertaking. A major weakness with both the Likert scales and semantic differential is the possibility of response bias on the part of the respondents, such as a tendency to choose extremes [Cronbach, 1946; Cronbach, 1950, pp. 25-26]. In addition, the semantic differential technique was deemed inappropriate for the present study because the information obtained is not directly related to the situation in a science classroom.

The multiple-choice item, most frequently using a Likert scale, was used for data collection not only on Kozlow and Nay's test, but on all instruments used in the present study. This format caters to two specific needs of the present study: objective and efficient scoring of large amounts of data.

In addition to affective attributes in the realm of science, another major area of attitudes is the set the student holds towards his school and towards science. It is important to recognize that affective learning is present in all classroom situations regardless of the teacher's conscious intentions. "Students continually form opinions about the value of the course, decide whether they enjoy their science study, and judge the importance of the subject in their lives" (Heikkinen, 1973, p. 2). "Everyone who learns something has some feeling about it

... no matter what we do, affective learning goes on anyway" (Kelly, p. 455).

Heikkinen (1973) used an experimental design very similar to that used in this study, however, his independent or manipulated variables were courses: Interdisciplinary Approaches to Chemistry (IAC) and non-IAC. Sex was also tested as a main effect variable. As in this study, Heikkinen used a five point Likert-type scale to measure student attitudes. His instrument contained 20 statements and was entitled Student Opinion Survey in Chemistry (SOSC).

Students were compared between the two courses and sex by means of two-way analysis of covariance procedures. The dependent or responding variable was SOSC. In addition SOSC was tested against TOUS, expected chemistry grades and the desire to take another chemistry course. I. Q. scores were also used in an attempt to predict SOSC scores using step-wise regression techniques as were several other variables including pretest SOSC scores, TOUS scores, course grade, enjoyment of past science courses and perceived need for chemistry.

Some of the findings: no discernible due to type of high school chemistry course; female attitudes towards chemistry were lower than male attitudes at the start of the year; female performance on TOUS was higher than males; striking decline in favorability toward studying chemistry during the school year for all sub-groups. From about half to two-thirds of the end of the course variance in student SOSC attitude scores could be accounted for by the previously mentioned variables.

Heikkinen (1973, p. 9) suggests that the influence of teacher characteristics and behavior in the classroom deserves investigation.

He further suggests that since different teachers bring science programs to life in different ways the "interaction of teacher variables with course materials and student characteristics probably holds promise for accounting for much of the variance remaining unexplained in final student attitudes" in his study. In fact, he suggests teacher variables "probably influence student interest and attitude even more critically than they affect measured gains of knowledge or skills evaluations" (Heikkinen, 1973, p. 9).

Two areas of attitude assessment appear: 1) attitudes to do with the affective attributes of scientists, and 2) attitudes towards school resulting from teacher-learning variables. Nay and Crocker provide a model for the first area and Kozlow and Nay constructed a measuring instrument. Heikkinen ran a study emphasizing a methodology for the second area and emphasizes the need for testing the significance of the teacher as a predictor variable and the need for more non-cognitive measuring instruments; both are objectives of this study.

Cognitive Domain

The cognitive domain "includes those objectives which deal with the recall or recognition of knowledge and the development of intellectual abilities and skills (Bloom, 1956, p. 7)". In science education the cognitive domain is characterized by major conceptual schemes around which the curriculum is usually planned. As such, a conceptual scheme represents an "area in science that has become firmly established in the scientific community" (Novak, 1964, p. 11). Different levels of under-

standing and study are possible for each conceptual scheme (Bloom, 1956, p. 18).

A science mark as given by a student's teacher is used to indicate the student's mastery of the system of facts, principles and concepts underlying each conceptual scheme. This mark represents what is commonly thought of as the cognitive domain. However, in attempting to measure the effects of teaching mode characteristics on student attributes in the cognitive and affective domains the distinction between the two becomes hazy. For example, students can also have knowledge of attitudes, processes and psychomotor skills. TOSA, the test developed by Kozlow and Nay (1975) includes a cognitive component or subtest measuring student's knowledge of what attitudes a scientist should exhibit in a given situation.

The present study should help identify which instruments are actually measuring different domains by considering the correlations. It is expected that very low correlations will exist between tests representative of the cognitive domain and tests representative of the affective domain.

Curriculum as an Indicator of Student Attributes

Many studies have been instigated by new courses or curricula being developed in the past two decades. Support for this type of study has two major motivating agencies: 1) the desire by educators to have a nice curriculum package yielding predictable results and 2) a publisher's or author's desire to show the superiority of his product. If the

curriculum utilized by a teacher has a significant effect on his student's behaviors this variable should be controlled in studies of the present type. Raun and Butts (see Figure 1) approached the design of their study by using science processes or strategies of inquiry as predictors for student changes in cognitive and affective behavior (Raun and Butts, 1967-68, pp. 261-269). They randomly selected 95 students from grades four, five and six in a single school in Texas and gave them pre and post tests in cognitive and affective areas. The intervening treatment consisted of five months of curriculum emphasizing selected strategies or processes of science. "The relationships between the criterion variable of behavior and the selected strategies of inquiry were tested by multiple linear regression" (Raun and Butts, 1967-68, p. 264). Performance in some of the processes correlated with some of the behaviors. However, on the basis of the definitions in this study only two of the four processes tested would be classified as processes: classification and observation. It is felt that using "number skills" and "space-time relations" more aptly qualify as behaviors in terms of the Raun and Butts study. Significant correlations were found between proficiency in the two stated processes and I.Q. and attitude to potency of science. Attitudes toward scientists, science recall and science problem solving were not significantly correlated with the two processes observation and classification ($p > 0.05$) (Raun and Butts, 1967-68, pp. 265-266).

It is suggested that not separating the curriculum from the teacher variable is significant in the resulting low identification of relationships between what occurs in the classroom and student achievements.

Montague and Ward (1967-68) studied the effectiveness of chemistry laboratory experiences involving investigative type experiences as compared with conventional type laboratory experiences. The control and experimental groups consisted of two classes. The control group performed laboratory investigations according to a "Chemistry workbook by Dull" (sic) while the experimental group performed a series of open-ended experiments. The same instructor taught both groups. On testing the two groups, Montague and Ward found no significant differences in critical thinking ability, problem solving ability, or understanding of science. They did, however, find that students having the investigative type experiences had a better understanding of principles of chemistry.

This study controls for teacher effects, which may be the most important variable, but uses an extremely small sample of two. The present study takes another, potentially important, variable into consideration: the desire of the student for a particular treatment or learning situation.

Hedley (1966) used a larger sample in comparing existing and experimental science programs in Manitoba Secondary Schools with respect to pupil achievement and attitudes. Twenty schools were selected and 458 grade ten students taking a general science course were compared with another group of 414 grade ten students, selected by random numbers from the same school, 349 of whom were taking a traditional science course and 65 of whom were in a Physical Science Study Committee (PSSC) Physics-Chemical Materials Study (CHEM) Chemistry program. The three groups were compared by analysis of variance on eight variables obtained from TOUS and SATS and representing student understanding of

science and attitudes toward science. In addition, he collected student I. Q. scores and gave a pretest indicating their prior science knowledge. He noted "discernible differences are to be found between the three groups of students" (1966, p. 142). Taking into consideration the covariance adjustment of prior knowledge and intelligence the PSSC-CHEMS students performed significantly better in all areas but one (understanding about scientists). They had superior scores on understanding about the scientific enterprise, understanding about the aims and methods of science, acceptance of text of the course, content of the course and the laboratory work in the course. As well, scores of the PSSC-CHEMS students showed them to be more involved in the course, more interested in the course and more satisfied that the course met their needs (Hedley, 1966, pp. 144-145).

Hedley reports a definite relationship between type of course and observed outcomes. For subsequent studies he recommends investigations of teacher characteristics in relation to resultant outcomes.

It is suspected the three groups Hedley tested may have been indicative of different populations and rather than use analysis of covariance in an attempt to make the groups equivalent a random assignment of students to the three treatments would be more acceptable for his purposes. Some doubt must exist as to what the predictor variables really were.

The present study can utilize Hedley's findings and suggestions in several ways: make sure all elements of the study sample have the same course and are heterogeneously grouped, investigate the effect of variable teacher characteristics and use I. Q. scores as a covariate if

necessary.

Summary

The preceding literature indicates the several facets involved in this study and represented by the model in Figure 2: the importance of inquiry-oriented instruction (Lewin, 1974; Nay, 1970; Nay and Associates, 1971; Goldman and Goldman, 1974; Bruner, 1962, 1971; Schwab, 1966); the need for using TMC as a predictor variable (Raun and Butts, 1967-68; Heikkinen, 1973; Hedley, 1966); the value of students and the teacher's peer group in providing information about the teaching-learning situation (Emmer, 1974; Harrison and Westerman, 1973; Elliot, 1974; Elam, 1974a; Thompson, 1975; Purchit, 1970); the existence of models and tests for attitude assessment (Nay and Crocker, 1970; Kozlow and Nay, 1976; Heikkinen, 1973; Hedley, 1966); and the importance of matching students with a desired environment (Hunt, 1974). These articles and research have been used to develop the design for this study.

CHAPTER III

DESIGN OF THE STUDY

A pilot study was carried out in 1968-69 to delimit, delineate and refine techniques and instruments which would be useful in identifying teacher mode characteristics and their impact on student attributes, particularly in the affective domain. First in this chapter the pilot study is discussed in substantial detail including design, results, data processing and major findings. Subsequently, the design for the main study is presented.

Pilot Study

The Problem

The pilot study was undertaken to deal with two main problems: 1) What methodology could most adequately be used to identify Teaching Mode Characteristics (TMC) which would be associated with resultant student attributes? and 2) Which measuring instruments would most adequately describe student attributes, particularly in the affective domain?

Statement of the Problem. What attitudes of junior high school science students specific aspects of science and their educational programs as well as their understanding of relevant science concepts can be identified when teaching mode is used as the predictor?

The Design

An attempt at classifying teachers on an inquiry-orientedness scale was made in order to see if any student attributes could be more easily associated with one teaching mode than another. The possibility existed that certain student behavioral patterns could be more successfully elicited if a low inquiry-oriented approach was used and that others could be more amenable to a high inquiry-oriented approach. To investigate these possibilities, teaching mode characteristics in the classrooms used in the study had to be identified so that they could be ranked as low inquiry or high inquiry-oriented and corresponding student responses to a set of questionnaires and tests be collected and correlated with type of teaching.

The model indicated in Figure 2 was used as the basis of the pilot study. The Teaching Mode Characteristics scores for the pilot teachers were determined by means of instruments and techniques to be described shortly. A limited version of the characteristics of inquiry-oriented instruction indicated in the table in Appendix A was used as a basis for preparation of the instruments. The inquiry-orientedness of the instruction was seen to be part of a continuum as indicated in Figure 3. The Teaching Mode Characteristics score indicated the relative degree of inquiry-orientedness of pilot teachers.

It was essential to utilize several different groups of raters of the Teaching Mode Characteristics. A review of the literature indicated utilization of the following groups for identifying the TMC: external evaluators, the teacher's peer group, the teacher himself and the teacher's students.

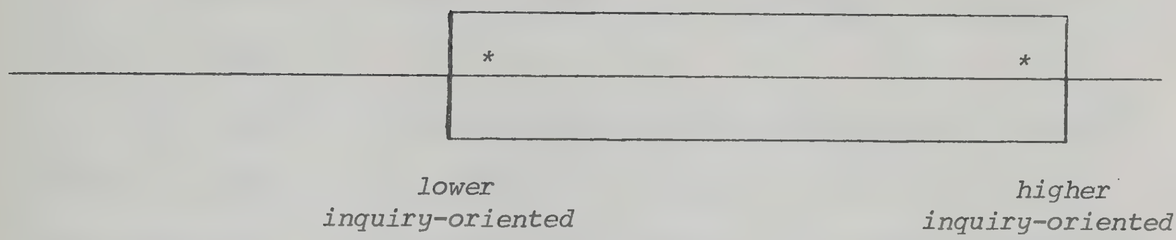

Figure 3

Teaching Mode Characteristics

Four separate TMC scores and rankings were determined as follows:

1. By External Evaluators: An instrument labelled "Inquiry Teaching" (Appendix C) was developed (Galbraith and Gay, 1968). The purpose of this instrument was to determine where on the continuum in Figure 3 a pilot study teacher should be placed. The process of classification involved observation by two external evaluators. Each teacher was visited at least twice at the convenience of the two evaluators, scores calculated and compared and a final composite score assigned to the teacher.

2. By a peer, the teacher and the students: A ten item questionnaire using a five point Likert-type scale, was constructed on the basis of the characteristics of inquiry-oriented instruction. The one for the students is indicated in Appendix D. Parallel forms were developed for the pilot teacher and the one peer used for rating, who in this instance was the science supervisor in the school system. (The student's form of the questionnaire was embedded in the HIFAMS questionnaire which

accounts for the extra items in that instrument in Appendices C, I and J.)

Four rankings of the teaching mode characteristics of the pilot teachers were obtained for subsequent comparison of ability to predict student behaviors: the teacher, their students, the science supervisor and two external evaluators.

The following instruments were used to measure students' cognitive and affective behaviors. The first four will be discussed in detail later under the "Main Study":

1. Student Attitude Towards Science (SATS).
2. How I Feel About My School (HIFAMS).
3. Test On Understanding Science (TOUS), Form Ew.
4. Sequential Test on Education Progress: Science, Form 3A.
5. Knowledge and Skills (K & S). A test patterned on Bloom's Taxonomy was developed by B. Galbraith especially for the students being considered in this study and was based on their science course content.

In addition to the results obtained for the five instruments mentioned above, I. Q. scores were obtained from the student's cumulative files and were found to have been derived on the basis of the Lorge-Thorndike intelligence tests. The reported score was an average of the scores obtained on the verbal and nonverbal batteries.

The Sample

The sample consisted of a group of twelve teachers all teaching the same course, Physical Science - A Lab Approach (PSLA), for the first

time, on a trial basis. The PSLA course is inquiry-oriented, hence any differences found in the inquiry-orientedness of teachers volunteering to try this course should be due to the idiosyncratic mode in which it was adapted and taught by each pilot study teacher.

It was deemed essential that the pilot study teachers teach the same course because Hedley (1966) found some differences in student attitudes towards science which he attributed to the different science courses being taught by his sample of teachers. That is, he attributed the variation in student attitudes toward science to differences in the science courses rather than to the differences in the way the science teachers taught them.

The teachers allowed visitations while their classes were in progress so that Teaching Mode Characteristic scores could be determined by means of the "Inquiry Teaching" instrument. Two evaluators, B. Galbraith and the writer, visited each classroom teacher a minimum of twice, each time for at least one complete period.

Hypotheses

The pilot study was designed to test the following null hypotheses:

Hypothesis 1:

When teachers are ranked as high inquiry or low inquiry-oriented by each of the four rating methods there are no significant differences between the students in the resultant groups in each classification as indicated by the criterion measures: SATS, HIFAMS, TOUS-Ew, K and S Test, STEP, I. Q.

Hypothesis 2:

When teachers are ranked as high inquiry or low inquiry-oriented by each of the four rating methods there are no significant differences between the students in the resultant groups in each classification as indicated by the criterion measures: SATS, HIFAMS, TOUS-Ew, K and S Test, STEP, when I. Q. is used as covariate.

Results

Instruments. As well as using the total test scores, factor analysis was carried out on each of the three instruments: HIFAMS, SATS and TOUS. This analysis was undertaken to check the construct validity of these tests since each reported constituent subtests measuring student perceptions on component factors. The HIFAMS factors remained somewhat similar to those originally proposed by the previous users, Coster and Pyra, (Pyra, 1965) but the factors for SATS and TOUS show considerable divergences from those postulated earlier (Hedley, 1966; Cooley and Klopfer, 1963a).

Teacher ranking. The teachers were ranked on a continuum from lower inquiry-orientedness to higher inquiry-orientedness on the basis of scores from each of the four rating methods: teachers, students, external evaluators and science supervisor. Classrooms in which all measuring devices were not administered were not used in the final analysis. Complete data were collected on nine classrooms and the bottom three and top three in inquiry-orientedness, as identified by each of the four teacher ranking methods, were used for four separate data analyses. That is, students of teachers with scores of one, two and

three were compared with students of teachers with scores of seven, eight and nine.

Table 3 shows how each of the methods ranked the teachers on the inquiry-oriented continuum. Each teacher is represented by a letter and the continuum is divided into categories of low (L), medium (M) and high (H) inquiry-orientedness.

Table 4 shows contingency tables indicating the relationships between the rankings. Assuming that the rankings are on an ordinal scale, the Spearman's coefficient of rank correlation is given below each table.

Criterion measures. Two groups of students for each ranking scheme were identified: those of teachers rated as low inquiry-oriented and those of teachers rated as high inquiry-oriented. These groups were then compared on each of the criterion measures. For example, the students of the teachers who ranked themselves as low in inquiry-orientedness were compared on all criterion measures with the students of the teachers who ranked themselves as high in inquiry-orientedness. Column one, under "Method Used for Teacher Ranking" in Table 5 and Table 6 show the results of these comparisons and as well the comparisons under the other three methods of classifying the teachers.

Table 5 contains the figures from an analysis of variance on pairs of measures and Table 6 is a summary of observed significant differences between the two groups under each ranking and on each of the criterion measures. Each student was assigned the TMC score his teacher received from each of the four ranking methods. Hence the degrees of freedom for critical values of F are (1, 5) since only six separate groups

TABLE 3

RANKING OF PILOT TEACHERS ON A LOW INQUIRY - HIGH INQUIRY SCALE

Method of Ranking	Inquiry-Orientedness								
	Low			Medium			High		
1. Pilot teachers (self)	[a]B	G	F	H	A	I	D	C	E
2. Students	A	B	C	D	E	F	G	H	I
3. External Evaluators	A	I	D	F	C	G	H	B	E
4. Science Coordinator	A	D	C	B	G	E	I	H	F

[a]The letters in Tables 3 and 4 stand for individual teacher identifications.

TABLE 4

CONTINGENCY TABLES: METHODS OF TEACHER RANKING

student \ self	L[a]	M	H
H	G	H, I	
M	F		D, E
L	B	A	C

$\rho = -0.05$

p[b] > 0.05

student \ external	L	M	H
H	I	G	H
M	D	F	E
L	A	C	B

$\rho = -0.07$

$p > 0.05$

self \ external	L	M	H
H	D	C	E
M	A, I		H
L		F, G	B

$\rho = 0.78$

$p < 0.05$

TABLE 4 (Cont'd)

Contingency Tables: Methods of Teacher Ranking

student \ science coordinator	L	M	H
H		G	H, I
M	D	E	F
L	A, C	B	

$\rho = 0.78$

$p < 0.01$

self \ science coordinator	L	M	H
H	C, D	E	
M	A		H, I
L		B, G	F

$\rho = -0.32$

$p > 0.05$

external \ science coordinator	L	M	H
H		B, E	H
M	C	G	F
L	A, D		I

$\rho = 0.17$

$p > 0.05$

[a] L indicates Low inquiry-oriented.
M indicates Medium inquiry-oriented.
H indicates High inquiry-oriented.

[b] p indicates the probability that ρ is significant.

TABLE 5

ANALYSIS OF SCORES OBTAINED BY STUDENTS OF TEACHERS RANKED AS LOW IN INQUIRY-ORIENTEDNESS AS COMPARED WITH THOSE OF STUDENTS OF TEACHERS RANKED AS HIGH IN INQUIRY-ORIENTEDNESS FOR EACH OF THE FOUR RANKING METHODS

Criterion Measures		Method Used for Teacher Ranking							
		Teacher		Student		External		Science Coordinator	
		Low	High	Low	High	Low	High	Low	High
TOUS	Mean Scores	23.78	23.51	22.94	24.94	23.28	23.84	22.87	24.62
	Variance	14.52	14.27	16.40	14.95	22.15	14.85	18.66	14.53
	p[a]	(<.01)		(<.01)		(<.05)		(<.01)	
	N	128	140	196	120	114	198	140	146
	F-Ratio	0.33		18.84		1.31		12.93	
	df	(1, 5)		(1, 5)		(1, 5)		(1, 5)	
	p	>.05		<.01		>.05		<.05	
HIFAMS	Mean Scores	26.54	27.24	27.89	24.75	27.65	26.73	28.41	25.38
	Variance	12.30	11.98	9.33	14.07	15.97	12.65	10.29	14.12
	p	(<.01)		(<.05)		(<.01)		(<.01)	
	N	125	136	189	115	110	190	135	100
	F-Ratio	2.57		67.33		4.18		44.19	
	df	(1, 5)		(1, 5)		(1, 5)		(1, 5)	
	p	>.05		<.01		>.05		<.01	

TABLE 5 (Cont'd)

Analysis of Scores .... Four Ranking Methods

Criterion Measures		Method Used for Teacher Ranking							
		Teacher		Student		External		Science Coordinator	
		Low	High	Low	High	Low	High	Low	High
SATS	Mean Scores	27.47	27.00	27.42	25.65	26.03	26.67	27.15	26.02
	Variance	20.55	19.36	22.38	14.17	13.16	19.24	19.96	13.54
	p	(<.01)		(<.01)		(<.01)		(<.01)	
	N	115	126	175	116	100	186	120	101
	F-Ratio	0.67		10.21		1.59		4.11	
	df	(1, 5)		(1, 5)		(1, 5)		(1, 5)	
	p	>.05		<.05		>.05		>.05	
STEP	Mean Scores	43.23	42.64	42.29	45.53	41.34	43.60	41.62	44.32
	Variance	50.89	43.04	47.11	29.23	54.27	45.16	47.01	37.03
	p	(<.01)		(>.05)		(<.01)		(<.01)	
	N	128	133	189	113	107	192	133	138
	F-Ratio	0.48		18.36		7.27		11.92	
	df	(1, 5)		(1, 5)		(1, 5)		(1, 5)	
	p	>.05		<.01		<.05		<.05	

TABLE 5 (Cont'd)

Analysis of Scores .... Four Ranking Methods

Criterion Measures		Teacher Low	Teacher High	Student Low	Student High	External Low	External High	Science Coordinator Low	Science Coordinator High
K & S	Mean Scores	36.46	34.55	33.51	39.62	35.86	35.88	34.13	28.20
	Variances	84.70	73.16	82.51	68.52	90.51	83.64	79.26	75.68
	p	(<.01)		(<.01)		(<.01)		(<.01)	
	N	160	122	176	107	100	185	122	132
	F-Ratio	3.16		32.12		0.00		13.59	
	df	(1, 5)		(1, 5)		(1, 5)		(1, 5)	
	p	>.05		<.01		>.05		< .05	
I. Q.	Mean Scores	117.8	115.8	115.1	121.5	115.8	116.8	115.3	119.4
	Variances	132.9	108.0	114.3	116.0	137.5	119.8	115.7	110.4
	p	(<.01)		(<.01)		(<.01)		(<.01)	
	N	169	129	188	111	102	192	129	134
	F-Ratio	2.28		24.98		0.44		10.07	
	df	(1, 5)		(1, 5)		(1, 5)		(1, 5)	
	p	>.05		<.01		>.05		<.05	

[a] The p value in parentheses represents homogeniety of variance.

TABLE 6

SIGNIFICANT DIFFERENCES ON EACH OF THE CRITERION MEASURES FOR STUDENTS OF TEACHERS RANKED AS LOW INQUIRY-ORIENTED AND STUDENTS OF TEACHERS RANKED AS HIGH INQUIRY-ORIENTED FOR EACH OF THE FOUR RANKING METHODS

Criterion Measure	Method Used for Teacher Ranking			
	Teachers	Students	External Evaluators	Science Coordinator
TOUS		**		*
HIFAMS		**		**
SATS		*		
STEP		**	*	*
K & S		**		*
I. Q.		**		*

** Indicates significance at the .01 level.

* Indicates significance at the .05 level.

are being compared: three under each ranking method.

No significant differences were observed between the students of high inquiry and low inquiry teachers as classified by the teachers themselves but the student groups resulting from the classification by the students were significantly different on all the criterion measures. A significant difference was noted in only one case for the student groups classified by the external evaluators but significant differences were noted in all but one case for the science coordinator's classification.

Table 5 presents the figures resulting from the analysis and Table 6 a summary of the results. In all cases where a significant difference is reported the desired or more positive score is in favor of the students of the teachers designated as high inquiry-oriented as compared with the students of the teachers designated as low inquiry-oriented.

Homogeneity of variance appears satisfactory using the Hartley test except for the STEP test under student rating of teachers. Checking this case with a t-test for significance of differences between means where population variances are unequal (Ferguson, pp. 171-173) does not allow retention of this result as reported in Table 5. Assumptions of analysis of variance will be discussed later.

Correlations of Criterion Measures. The correlations between the different criterion measures are given in Table 7. These correlations were calculated on the test results of forty students randomly sampled from the total sample. Correlations with the two attitude measures could not be made since student anonymity was guaranteed and no identification was put on either the HIFAMS or the SATS papers.

TABLE 7

CORRELATIONS BETWEEN PAIRS OF CRITERION MEASURES

$N = 40$

	I. Q.	STEP	K & S	TOUS
I. Q.				
STEP	0.42			
K & S	0.37	0.25		
TOUS	0.06	0.32	0.07	

Analysis of Covariance. Using a random sample of 75 students from each of the two groups resulting from student classification of teachers and performing an analysis of covariance, with I. Q. as covariate, did not significantly change the means on the three instruments: TOUS, STEP, K & S. The data from this sampling appear in Table 8. The significance of the results for TOUS have risen above the 0.01 level as indicated in Table 8 but the others remain significant at the 0.01 level. It is suspected that the TOUS differences would also remain if all the data were considered. Thus I. Q. scores have little effect on the reported student differences. HIFAMS and SATS were not tested here since they contained no student identification.

Discussion

The correlations between the methods of ranking the teachers on the inquiry-oriented continuum should be noted. The correlation between the view that the teachers have of themselves and the view the students have of them is almost zero. Conversely the student ratings agree significantly with those of the science coordinator. (A t-test shows the correlation to be significant at the 0.01 level.) Rating by the external evaluators correlated most highly with that of the teacher's self-rating.

The students who viewed their teachers as more inquiry-oriented as indicated by their answers to the questionnaire scored significantly better on the knowledge tests, attitude tests and the Test On Understanding Science and also had higher I. Q. scores. After statistically removing the effect of I. Q. the other results still remained signifi-

TABLE 8

CHANGES IN CRITERION MEANS RESULTING FROM USE OF I. Q. SCORE AS COVARIATE

N = 150

Criterion	Students of Low Inquiry-Oriented Teachers		Students of High Inquiry-Oriented Teachers		F-Ratio			
	Mean	Adjusted Mean	Mean	Adjusted Mean	ANOVA	Adjusted ANOVA	df	p
TOUS	23.12	23.19	24.77	24.77	6.56	5.37	(1, 147)	.05
STEP	42.08	42.26	45.44	45.26	12.28	9.67	(1, 147)	.01
K & S	33.49	34.13	39.21	38.56	16.02	13.33	(1, 147)	.001

cantly different. In addition the students who did well in one area, as indicated by the six criterion measures, were found to do well in all areas. In particular, the areas considered, labelled as affective and cognitive in Figure 2, showed that students who scored highly in one area as a group also scored highly in the other.

Similar student results were observed when the science coordinator ranked the teachers.

It appears that different teaching mode characteristics do result in, or can be associated with, different student behaviors. However, the important variable in this association appears to be the group chosen to identify the TMC. Since the successful groups for predictive purposes in the pilot study were the students and the science consultant perhaps the TMC raters must be personnel who associate frequently with the teacher. That is, they must be familiar with the teacher but cannot be the teacher himself.

Implications for the Main Study

The pilot study was undertaken to gather information relevant to the design of the main study. As a result of the pilot study it has been ascertained that Teaching Mode Characteristics can be used as a method of identifying inquiry-orientedness of a classroom, and depending on who does the rating the resultant classifications correlate with certain student behaviors.

The raters of most promise appear to be the teacher's peer and his students with the correlation between these ratings and the teacher's self-rating being of significant interest. These three groups will be

retained as raters of TMC for the main study.

Since the students of teachers rated as high in inquiry-orientedness had higher I. Q. scores than the students of teachers rated as low in inquiry-orientedness the question arises, "Does the student with higher I. Q. view his teacher as more inquiry-oriented?" Also, perhaps teachers react to students with higher I. Q. scores in a higher inquiry-oriented manner. These associations should be further investigated.

Further development and analysis of items on the teacher ranking questionnaire should prove revealing with respect to individual student differences within a classroom. Also, it would be desirable to perform an analysis of variance on the methods used to identify TMC to ascertain the significance of differences between raters.

To actuate the above analysis and more adequately answer the initially proposed problem of relating given teaching mode characteristics to student behaviors data should be collected on individual student rankings of teachers and the criterion measures. To do this student identification on all criterion measures is necessary. In addition, this identification is needed to calculate correlations between all pairs of instruments. These correlations should indicate the degree to which the criterion measures are measuring different student behaviors from the cognitive and affective domains.

Factor analysis of HIFAMS, SATS and TOUS, to be discussed later, indicates HIFAMS subtests can be used as they parallel those in the original form (Pyra, 1965). However, only total scores from SATS (Hedley, 1966) and TOUS (Cooley and Klopfer, 1963) will be used since factors from

these tests bore no relationship to those proposed by their authors.

The main study will incorporate these findings into the design.

Main Study Design

Descriptions of the sample and population are presented in this section. Subsequently details of the testing instruments including results of factor analyses are given. The testing program follows and finally data processing techniques used are described.

Population of the Study

Arrangements for carrying out the study were made through the Director of the Curriculum Branch for the Alberta Department of Education. Letters were sent to principals of all the junior high schools in Alberta requesting them to pass on the information to each of their grade nine science teachers (Appendix E). The Department of Education List of Operating Schools in Alberta indicated that approximately 600 schools in the Province of Alberta offer grade nine and hence Science 9. Of these schools approximately 140 are in Calgary or Edmonton, the two major urban areas.

Teachers from 250 schools throughout the province volunteered to take part in the study and from these 130 were chosen at random to participate; 120 ultimately did. The chosen schools provided approximately 5,000 students to respond to the instruments measuring student behaviors. Schools in this study represent approximately sixteen per cent of the total number (800) of towns, cities, or villages, on an official provincially published 1975 map of Alberta.

Furthermore, the province is divided into six zones, each one

consisting of a group of school jurisdictions, including divisions, counties and urban districts which make up a high school inspectorate (See Appendix F). The distribution of schools per zone is shown in Table 9. The populations of the centers in which the schools are located are shown in Table 10. The majority of the schools are in centers of populations less than 5,000 although several schools from larger centers are also included in the sample.

Table 11 shows that the majority of teachers teach three Science 9 classes or less and are the only Science 9 teachers in the school. As well very few classes consist of students who are assigned to a particular class but are free to choose which section they will attend if more than one is available. Even where students are assigned it is rarely done on an ability basis but is more likely to be the result of organizing the program for facilitation of the option program. That is, almost all classes can be expected to be heterogeneous.

As will be discussed and illustrated later (Table 18) different classes wrote different combinations of six student behavior instruments. The combination of tests a specified class was requested to write was randomly assigned but resulted in each test being reasonably represented throughout the province (Table 12).

The population as described above should be reasonably representative of the Province of Alberta and statistics obtained from these schools and classes will be referred to as population statistics.

For purposes of hypothesis testing a sample of the above described population was selected. This sample, to be described in detail later, consists of those classes that wrote all the student attribute

TABLE 9

NUMBER OF SCHOOLS PARTICIPATING IN THE STUDY FROM EACH PROVINCIAL SCHOOL SYSTEM ZONE[a]

Zones	Number of Schools
1	16
2	16
3	38
4	24
5	11
6	15
TOTAL	120

[a]See Appendix E for geographic distribution of Zones.

TABLE 10

DISTRIBUTION OF SCHOOLS ACCORDING TO POPULATIONS OF CENTERS

Population	Number of Schools
Under 250	32
250 - 1,000	29
1,000 - 2,500	16
2,500 - 5,000	19
5,000 - 10,000	8
10,000 - 25,000	5
25,000 - 50,000	6
50,000 - 100,000	0
Over 100,000	5

TABLE 11

CHARACTERISTICS OF ADMINISTRATIVE ORGANIZATION OF SCIENCE LEARNING SITUATIONS IN THE STUDY

Characteristic	Number of Teachers in Each Situation
Number of Classes Taught	
1	62
2	27
3	17
4	9
5 or more	5
Number of Science 9 Teachers in the School	
Only one	99
More than one	21
Student Assignment to Classes	
Students attend class of their choice	110
Students are assigned to a specific class	10

TABLE 12

NUMBER OF CLASSES IN EACH SCHOOL SYSTEM ZONE

RESPONDING TO EACH TEST

Tests	Zones						Total
	1	2	3	4	5	6	
SLSI-T	17	16	31	18	11	16	109
SLSI-TA	13	6	18	11	5	9	62
SLSI-S	18	16	33	20	11	16	114
TOUS-Ew	12	13	29	14	8	11	87
I. Q.	13	11	27	12	10	10	83
Science Mark	13	11	28	13	9	10	84
TOUS-Jw	11	7	24	14	5	10	71
HIFAMS	15	13	32	19	10	14	103
SATS	15	12	29	16	9	14	95
TOSA	15	10	31	14	9	14	93
STEP	1	0	3	2	1	1	8

instruments. This sample included six teachers and their 482 students.

Due to the extensive coverage of the Province, instrument scores obtained should be applicable to most of the grade nine science classes in Alberta and to a more limited degree to other classes with characteristics approaching those described above. In addition, for generalizability, the time of year in which the data were collected must be considered; testing occurred during the months of February, March and April.

Thus, instrument statistics are referred to as those of the population and comparison of the scores with those obtained from the sample used to test the hypotheses will indicate the degree to which the findings will be generalizable.

Testing Instruments

Treasure discusses the characteristics of measurement labelled "validity" (1965, pp. 58-59). The various types of validity may be characterized as "content", "construct", "predictive" and "concurrent".

> Content validity usually refers to the correspondence between the test items and the attributes or knowledge being tested. An appropriate technique for checking this correspondence of items with the attribute being measured involved the use of competent judges. There is bound to be some disagreement over the items; however, Bloom, Hastings, and Madaus (1971, p. 76) suggest that 75% agreement or better is satisfactory while less than 50% agreement should be cause for alarm.
>
> Construct validity is a characteristic of most ability or personality tests and refers to the relationship of the items that measure the same trait or group of behaviors. A measure of construct validity is the correlation of one item or group of items with others and the extent to which there are common factors within a test.

Predictive validity is a characteristic of ability measures and is a measure of the degree to which the items in whole or part correlate with either subsequent actions or test performance. This presupposes some sort of logical relationship between the test and a criterion.

Concurrent validity is the extent to which student performance on one test is the same as their performance on some previously established standard. For example, one might suppose that the rank order of students writing a highly verbal test might remain in the same relative position on a verbal-ability test. This is of most use in establishing the relation between an indirect and a more direct measure of some behavior.

These criteria for adequacy of tests are used in the following discussions of instruments used in the present study.

As indicated in the model representative of the present study (Figure 2) instruments are required to measure three major areas: 1) teaching mode characteristics, 2) student behaviors in the affective domain and 3) student behaviors in the cognitive domain. The *Science Learning Situation Inventory* was developed to meet the first requirement. To measure student behaviors from the affective and cognitive domains the following instruments are employed: HIFAMS, SATS, TOSA, TOUS-Ew, TOUS-Jw, STEP (Science), and a Science Mark. In addition, I. Q. scores are also used as criterion measures.

Test on Understanding Science (TOUS) was developed as a result of the re-examination and radical revision of science curricula in America between 1957 and 1959. Its intent was to go outside the traditional content evaluation and, in addition measure students' understanding of scientists and the scientific enterprise (Buros, 1972, p. 1240; Cooley and Klopfer, 1963a, 1963b).

H. Grobman and V. Noll report separately on TOUS (Buros, 1972, pp. 1241-1245). It is reported that more than one form exists and given

descriptions are inclusive of earlier versions than the form W on which the reports are based (Buros, 1972, p. 1240). Two forms of TOUS are used in the present study: TOUS-Ew and TOUS-Jw. The degree to which the descriptions given in Buros actually are applicable to the forms used is unknown. However, using two forms enables the calculation of their correlation and hence an indication of alternate-forms reliability (Guilford, 1965, p. 445).

The two reviews given describe several significant aspects of the tests. Content validity was established by science educators concerned with the history of science. But since this was done in 1960 some of the qeustions may not currently be appropriate. The test consists of three major areas, understanding about: 1) the scientific enterprise, 2) the scientist and 3) the methods and aims of science. Factor analysis of the pilot study version did not identify three major factors but several factors not coinciding with test manual classifications. However, if as is stated in Buros (1972, p. 1242) the test can be further analyzed into themes some logical relationships may result.

Item difficulties are reported to range from 0.09 to 0.90, KR_{20} to be 0.76 for the total score and grade correlations with Otis raw scores ranging between 0.64 and 0.69 (Buros, 1972, p. 1244). The pilot study identified a correlation of 0.06 between Form Ew and the Lorge-Thorndike average of verbal and non-verbal scores. The correlations with I. Q. scores reported in the main study are 0.51 and 0.49 for the two forms used (Table 27). The correlation between the two forms is 0.66 (Table 27). This low correlation indicates the tests are considerably different and thus both should be used.

The intended purpose of TOUS was for research only and, as was suggested in Buros, it should be used and interpreted with caution. The test manual is not complete and further development of the test is desirable as such an instrument is desirable (Buros, 1972, pp. 1242-1243).

Results obtained from the two forms used in this study are probably most useful when considered in relation to the other student test results. In addition, data are provided by this study for revision and development of an appropriate Alberta form (should the authors so consent).

Lorge-Thorndike Intelligence Tests (K-12) and the Otis Quick Scoring Mental Ability Test. *These two I. Q. tests were used to about an equal extent in the Province of Alberta at the time of this study.*

Both the Lorge-Thorndike and the Otis tests cover the desired grade level for this study. Specifically, the Lorge-Thorndike test has two forms for grades 7-9, a verbal and non-verbal, and the Otis test, form Beta, which is administered from grades 4 through 9.

Lorge-Thorndike Intelligence tests received a favorable report from Tittle (Buros (ed.), 1972, pp. 684-686). Reliabilities (KR_{20}) from 0.80 to 0.91 were obtained for different grades. Correlations with school achievement rated as moderate to fairly high. Verbal scores usually provide higher correlations than non-verbal scores in predicting achievement although both produced relatively high correlations from 0.60's to 0.80'.s Validity discussions in the technical manual were reported as good.

The Otis test appears to have an excellent and long standing reputation although the instrument is currently being updated (Buros,

1972, p. 685). Only one score, loaded toward the verbal competency aspect, is produced.

Correlations between the Lorge-Thorndike Non-Verbal and Verbal scores and Otis Non-Verbal score are, respectively, 0.72 and 0.85 (Lorge and Thorndike, 1957, p. 13).

Teachers were asked to report I. Q.'s as they appeared on the cumulative records. The I. Q.'s thus reported should be a fairly even split between the Lorge-Thorndike and the Otis. Since the two tests have similar standard deviations and are reasonably highly correlated their scores are used as a single variable for subsequent statistical calculations in the present study. This strategy is statistically questionable but is utilized for the following reasons: these scores may have as much construct, predictive and concurrent validity as scores from the same test given at different grade levels (teachers were asked to report the most recent score), a large number of tests were given in the present study and the addition of an intelligence test was decided to be undesirable, the I. Q. score should be at least as valid (predictive) as the science mark which teachers were asked to predict, and I. Q. is not considered a major variable in the present study but is mainly desired for comparison purposes with other student behaviors.

Sequential Tests of Educational Progress (STEP), Science, Form 3A, 1962. STEP tests were produced in two forms in 1956-1957 by the Cooperative Test Division of the Educational Testing Service. Form 3A developed for grades 7-9 was used in this study as a measure of student achievement on a standardized science knowledge instrument.

Johnson reports these tests assume that by utilizing problem situations to measure the student's ability to use basic scientific concepts they are also measuring the understanding and retention of basic scientific concepts (Buros, 1959, p, 802). He further states the test is comprised of sets of multiple choice questions based on a single problem situation, "the problems included being those deemed to be of concern in the everyday life and interests of the students" (Buros, 1959, p. 802). In addition, there are several attempts to test understanding of the scientific method: defining problems, suggesting hypotheses, etc. Norming was done on schools that volunteered to participate and since representative qualities of schools included are now known, utilization of published norms is "very hazardous" (Buros, 1959, p. 802).

Jackson reports the test is given an excellent rating for use by everyone from the classroom teacher to the most statistically oriented measurement specialist (Buros, 1959, pp. 67, 804). Jackson's review includes Kuder Richardson formula 20 reliability scores for the STEP tests which he reports range from 0.84 to 0.92 (Buros, 1959, p. 63). Validity [concurrent] is referred to by giving correlations to SCAT which are "quite high" such that there is doubt that both measures would have to or should be administered to the same students (Buros, 1959, p. 64).

Although validity and reliability information are not necessarily complete for the population tested here, this test seems appropriate for utilization in the present study for group comparisons and correlations with other measurement instruments.

Science Mark. Towards the end of the school year the teacher was asked to submit a final mark in science for each student. The

validity and reliability of these marks is an open question identical to that attached to any set of marks reported by teachers at the year's end. However, since all schools are accredited and no standard final exams exist, the student's final marks in all areas are those assigned by the teacher.

A potentially valuable aspect of this study is the statistics attached to, and correlations between, reported science marks and the other student behavior measuring instruments. In particular are the marks inordinately high? Do they correlate with STEP and I. Q.? As a result of accreditation can any implications be made on the teacher's ability to assign marks in isolation of provincial standards?

Test on Scientific Attitudes (TOSA) was developed by J. Kozlow and M. A. Nay for use in a study on measurement of scientific attitude.

Kozlow used the Nay-Crocker inventory (Nay and Crocker, 1970) of affective attributes of scientists as a framework for dealing with affective attributes in science education. He focused only on the attitudes given in this inventory which he defined behaviorally. A test of forty multiple choice questions was developed to measure the attitudinal behavior of students, which was named the Test on Scientific Attitudes.

TOSA is divided into two subtests, one measures students' knowledge of how scientists behave attitudinally in their research activities. The other subtest measures students' attitudinal intent by presenting them with various problem situations in the test item stem to which they have to respond. These subtests are labelled Cognitive Component

Subtest (CCS) and Intent Component Subtest (ICS), respectively (Kozlow and Nay, 1976, p. 153).

The KR-20 coefficients for TOSA, TOSA-CCS and TOSA-ICS are 0.55, 0.45 and 0.39 respectively. Although these are low the test-retest correlations are 0.71, 0.68 and 0.64 which are more satisfactory (Kozlow, 1973, p. 100), and indicate reasonably good test stability. The population consisted of Chemistry 20 and Physics 20 classes in the Edmonton Public School System. TOSA was administered twice, once in the spring semester to 156 students and once in the fall semester to 151 different students, 105 of whom wrote the test twice providing test-retest data (Kozlow, pp. 54-55).

SCAT (Form 3A) and STEP reading (Form 3A) scores were obtained from 1971 grade 9 records at the Department of Education. The correlations between total SCAT and STEP scores with TOSA are 0.33 and 0.35 respectively. The correlation between the two subtests of TOSA is 0.23 indicating these two subtests are not measuring the same characteristics. Item analysis was performed on the test and resulting statistics (means, standard deviations, ranges, frequency distributions, correlations) indicated most of the items were satisfactory (Kozlow, 1973, pp. iv, 71-74).

Content validity is based on the argument that "the attitudes which the test is designed to measure were selected from a list of affective attributes of scientists, the behavioral specification of these attributes were selected on the basis of the responses of a panel of judges", the items described science-related situations and the keyed responses were derived by a panel of judges (Kozlow, 1973, pp. 68-69).

Structural (construct) validity is discussed by Kozlow under two aspects: item analysis to obtain properties of the individual items and test-homogeneity as well as factor analysis to examine the underlying structure of the test items. Generally item difficulties are acceptable being within the range 0.11 to 0.87. Biserial correlations were calculated for each test item with the total test score and with the two subtest scores. Most of the biserial correlations for the items and their subtests are above 0.30 and "should be satisfactory" (Kozlow, 1973, p. 79).

The homogeneity of the sample subjects would tend to lower the homogeneity of the test (Kozlow, 1972, p. 85) and could account for the relatively low KR-20 coefficients of 0.55, 0.45 and 0.39 for the three aspects of the test noted above. Even though the sample used was homogeneous the relatively low KR-20 coefficients indicate some item revision may be desirable (Kozlow, 1972, p. 84).

Factor analysis showed reasonably good "agreement between the theoretical classification and classification by the factor solution". Approximately 80% of the salient factor loadings can be related to the item classification which was based on the definitions of the attributes (Kozlow, 1973, pp. 99-100).

An attempt was made to ascertain the external [concurrent] validity of TOSA by having the teachers rate the attitudinal behavior of their students and then compare these ratings with student performance on TOSA. Owing to probably misunderstanding by the teachers of the nature of the rating task no significance could be attached to the information obtained for the external [concurrent] validity of TOSA.

Although TOSA is only a "first step" (Kozlow, 1973, p. 123) in affective instrument development it has many desirable features which make it appropriate for the present study: it is unique in its objectives, it has a cognitive component, it has an affective component, it has been rigorously developed. An additional desirable outcome of the use of TOSA will be considerable additional information as to its statistics with a much larger group and with a different grade level.

The Science Learning Situation Inventory (SLSI). SLSI was expanded from the ten item questionnaire used in the pilot study, (See Appendix D) and the "Inquiry Teaching Instrument" (See Appendix C).

The new enlarged version provides not only information on how the student perceives his actual teaching-learning situation (SLSI-A) but also provides a score indicating the type of situation he thinks he desires (SLSI-D). The difference between these scores, (D-A), then indicates the degree to which the student is satisfied with or matched with the science learning situation he desires. To ascertain this score a procedure similar to that used by Cheong and DeVault (1966) was utilized in that students are asked to respond twice to many of the statements describing their teaching-learning situation: once with respect to the degree that they desire the characteristic described (D-score), and once to the degree that they are actually experiencing that situation (A-score). The majority of the items on the SLSI test provide a score indicating the degree of inquiry-orientedness of the students' teacher, SLSI-TMC. The items in SLSI-A are included in this score. As well, the student receives a total score on the questionnaire used for com-

parison purposes with the subtest scores: SLSI-TMC, SLSI-A, SLSI-D and D-A.

Table 13 presents a breakdown of the number of items and subtests in the SLSI-S instrument. Table 14 presents the correlations between the sets of scores described above and the probability that each correlation is zero. The sample (482) students are used for these calculations.

The scores of greatest interest here are SLSI-TMC, SLSI-A and SLSI-D since they are to be used for subsequent analyses. The high correlations between SLSI-S, SLSI-TMC and SLSI-A are expected since the three scores to a large degree contain the same items (Table 13). Also of importance is the low correlation between SLSI-A and SLSI-D (0.24) since these scores are to be subtracted to result in a student and science learning situation matching score. For difference scores to have reliability they must have a low intercorrelation. As the correlation of two scores depart "in a positive direction from zero, the error variance accounts for an increasing proportion of the total variance of differences, with a resulting decrease in reliability" (Ferguson, 1966, p. 383).

That this desirable relationship of low correlation exists between the D and A scores is enhanced by calculating the first order partial correlation coefficient between these two scores with the SLSI-TMC score eliminated as the third variable. Using the formula given in Ferguson (1966, p. 389) the resultant partial correlation coefficient is 0.02. Testing whether this partial correlation coefficient is significantly different from zero using the t-test (Ferguson, 1966,

TABLE 13

STRUCTURE OF SLSI-S

Total Test and Subtests	Item Numbers	Number of Items
SLSI- S	1-62	62
SLSI-TMC	2,4,6,8,10,12,14,15,17,19,21,22,24, 25,27,28,30,31,33,35,37-62	46
SLSI-D	1,3,5,7,9,11,13,16,18,20,23,26,29, 32,34,36	16
SLSI-A	2,4,6,8,10,12,14,15,17,19,21,22,24 25,27,28,30,31,33,35,37	21

TABLE 14

CORRELATIONS BETWEEN SLSI-S AND ITS SUBTESTS

(THE UPPER TRIANGLE CONTAINS THE

PROBABILITIES THAT $r = 0$)

$N = 482$

Test or Subtest	SLSI-S	SLSI-TMC	SLSI-D	SLSI-A
SLSI-S	1.00	<0.001[a]	<0.001[a]	<0.001[a]
SLSI-TMC	0.95[a]	1.00	<0.001[a]	<0.001[a]
SLSI-D	0.55[a]	0.26[a]	1.00	<0.001[b]
SLSI-A	0.84[a]	0.88[a]	0.24[b]	1.00

[a]As indicated in Table 13 these correlations are between scores which have items in common and therefore represent self-correlation to some degree.

[b]SLSI-A and SLSI-D scores are based on different test items.

p. 390) with df = 479 indicates it is not ($p < .01$).

That is, using $v = 0.24$ the D and A scores have $R^2 = 0.07$ or only seven per cent of their variance in common. The residual relationship between these two variables is insignificant when the common influence of the third variable, SLSI-TMC, is removed.

Thus both the correlation and partial correlation calculations support the earlier stated condition for reliability between difference scores: that the correlation between the two scores approach zero.

In addition, the Science Learning Situation Inventory: Student's Version was processed by the DERS factor analysis package using item data from 1346 students chosen randomly from the population. This program carries out a principal components analysis from the raw data. Varimax, Quartimax and Equamax orthogonal rotations are applied to the principal components solution. The varimax rotation was chosen since it "serves to maximize the interpretability of factors by simplifying them so that each factor has only a minimum number of variables with large loadings on it" (Mulaik, 1972, p. 259). Since the instrument SLSI-S, has two subtests designed to measure discrepancies: what the student is actually experiencing (SLSI-A) and what the student desires (SLSI-D), and analysis should show the items appearing as distinct factors and hence indicate construct validity. As well, to indicate construct validity the analysis should identify a simplified description of the factors contributing to the students perceptions of his learning environment: both actual and desired.

Seven factors were chosen as a result of inspecting the preliminary analysis which produced sixteen eigenvalues of 1 or larger. The sixteen factors represented the eigenvalues of 1 or more accounted for

53.3% of the common variance. The seven variables which were retained accounted for 36.1% of the common variance indicating a high degree of uniqueness among the remaining factors; only two items failed to load on any factor when coefficients of less than 0.30 were considered as the point below which their contribution to the variance of the factor was not significant.

Table 15 presents the results of the Varimax rotation which maximizes the loadings on the seven selected factors. The last column contains the communalities of the questionnaire items which represent that portion of the item variance which each item has in common with the other items.

Definitions of Factors. A listing of all the Factors and items appears in Appendix H. A general description of the Factors follows:

Factor 1 has loadings from items used to describe what students learn about scientists and the nature of science.

Factor 2 has loadings from items used to describe the type of science-learning situation (TMC) a student is experiencing (A-score). The items center around the variety of activities offered.

Factor 3 also has loadings concerned with TMC but centers around the attention paid to the processes of science (A-score).

Factor 4 has loadings from items describing the science learning environment of TMC a student desires (D-score).

Factor 5 has loadings from items concerned with the nature of a scientist.

Factor 6 has loadings from items describing the amount of time a student gets to spend acting like a scientist.

TABLE 15

VARIMAX ROTATED FACTOR MATRIX FOR SLSI-S

Item	FACTORS							Communalities
	1	2	3	4	5	6	7	
1							37	18
2							42	30
3				34				19
4					33			25
5				34	46			38
6					62			45
7				51				30
8		49				32		41
9				39	46			43
10					66			50
11							36	24
12							52	38
13				50				31
14		63						48
15		60						47
16						38	-31	42
17					47			41
18				58				37
19		51						32

TABLE 15 (Cont'd)

Varimax Rotated Factor Matrix for SLSI-S

Item	Factors 1	2	3	4	5	6	7	Communalities
20				47				32
21			55					37
22			55					44
23				57				38
24			33					27
25			38			36		38
26				51				40
27			63					51
28			60					49
29			31	50				44
30		32	60					50
31			62					52
32				41				23
33						31		26
34				40				19
35						53		36
36				47				29
37		41	35					36
38						55		35
39		38				31		33

TABLE 15 (Cont'd)

Varimax Rotated Factor Matrix for SLSI-S

Item	Factors							Communalities
	1	2	3	4	5	6	7	
40								12
41							55	33
42		67						51
43		68						56
44						37		22
45						30		20
46								22
47	32				43			40
48					39			36
49	50							39
50	60							40
51	57							45
52	37							35
53	58							48
54	30					32		28
55	51							32
56	48	34						42
57	39							24
58	56							44
59	58							44

TABLE 15 (Cont'd)

Varimax Rotated Factor Matrix for SLSI-S

Item	Factors							Communalities
	1	2	3	4	5	6	7	
60	51							42
61	61							47
62	32					34		26
Variance	4.6	3.9	3.7	3.3	2.6	2.5	1.8	Sum 22.42
% of Total Variance	7.3	6.3	5.9	5.3	4.2	4.0	3.0	
% of Common Variance	20.5	17.4	16.5	14.7	11.6	11.2	8.0	
Number of Items	15	10	10	13	8	11	6	

Total Variance accounted for 36.1%

Note: The entries in the above matrix have been multiplied by a factor of 100 and rounded to the nearest whole number. Loadings less than 30 have been dropped.

Factor 7 has loadings from items centered on the reactions or responses of the teacher to various science learning situations.

KR-20 coefficients for SLSI-S, SLSI-A, SLSI-D and SLSI-TMC were calculated. These coefficients were, respectively 0.89, 0.71, 0.80 and 0.84. Using the formula for reliability of difference scores (Ferguson, 1966, p. 383) the reliability of the D-A score is 0.68.

The construct validity is strongly supported by the factor analysis in two crucial areas, SLSI-D and SLSI-A. SLSI-D comes out very strongly as Factor 4 and SLSI-A as Factors 2 and 3. Two of the items that loaded on more than one factor had their double loadings on Factors 2 and 3. In addition, earlier indications that the utilization of the processes of science could be a strong indicator of TMC is suggested by the existence of Factor 3.

The high correlation between SLSI-A and SLSI-TMC is expected since many of the items are common.

Factors 1, 5, 6 and 7 are also seen to be grouped around common themes showing a relatively logical, uncomplicated structure. This characteristic supports content and construct validity.

The major purposes for which this instrument was intended are thus supported by the correlation and factor analysis results. Factor analysis identified the SLSI-D and SLSI-A components plus a simple pattern of factors describing the science learning situation. The very low correlation between the SLSI-A and SLSI-D subtests indicate difference scores involving these can be utilized.

How I Feel About My School (HIFAMS). This instrument (Pyra, 1965) contained 31 items with the function of measuring student attitudes

towards:

a. Teachers

b. Appropriateness of school work

c. Future expectations

d. Social acceptance

e. School climate.

The test uses a multiple-choice response pattern and (Pyra, 1965, p. 42) the items were scored by arbitrarily assigning a scale value of five to the responses judged to represent the most favorable attitude, and a value of one to the least favorable attitude. Scale values of four, three and two were assigned to the remaining responses.

To determine the reliability of the total questionnaire the test-retest method was used (Pyra, 1965, p. 42). The reliability coefficient obtained as a result of retesting four weeks after the original run was 0.96. Pyra also reports that the reliability of the scale was obtained by determining the coefficient of correlation between the sub-total scores made on odd-even numbered items (1965, p. 41). The ensuing split-halves reliability coefficient using Spearman-Brown's formula was 0.91. Data from the pilot study yielded an alpha reliability coefficient of 0.85. This program calculates the alpha reliability coefficient by using the variance-covariance matrix and is a measure of internal consistency.

In addition to the 31 items mentioned above the test also contains an item requesting the students indicate their sex and, as well, the ten items students used for rating of Teaching Mode Characteristics in the pilot study are also included.

One of the functions of the pilot study was to ascertain usefulness of instruments for the main study. Hence item data from 401 students from the pilot groups were used to factor analyze HIFAMS using the Equamax orthogonal rotation. The Equamax rotation was used because it "tends to distribute the variables more nearly equally across the different factors, and so the factors will appear more interpretable" (Mulaik, 1972, p. 264). This appears desirable in a test of this type where a given question can logically load on more than one factor. A major purpose of this analysis was to check the author's breakdown of items in the test which was written before computer facilities were readily available and hence check the construct validity of the test. Also, it was felt the analysis was necessary since ten items were added and the study population changed from high school to junior high school.

Since the test contained ten extra items in the present study, and one item requesting identification of sex, the instrument was factor analyzed twice, once with all items except sex included and once with the sex item and four TMC items which didn't load removed. The first analysis produced twelve factors with Eigenvalues greater than 1.0. The second analysis produced exactly eight factors with Eigenvalues greater than 1.0 which accounted for 57.8% of the common variance. This low percentage indicates a high degree of uniqueness in the test items or total test variance that is not shared with other items (42.2%).

Table 16 shows the results of the Equamax solution which equalizes the variance over the eight factors.

The eight HIFAMS factors, their definitions and a summary of the stem of each component item are as follows:

TABLE 16

EQUIMAX ROTATED FACTOR MATRIX FOR HIFAMS

Item	FACTORS								Communalities
	1	2	3	4	5	6	7	8	
2			48*						43
4		55*							55
5			55*						46
6			47*	43*		36			66
7			40*				40*		51
8	70*								67
9					73*				66
10	64*							20*	64
11								61*	61
12			55*			32			51
13	28*			47*					44
14								77*	67
15		52*				42*		30*	65
16	37*	36	30*	33					56
17			47*	35		32			64
18							85*		74
19			35			57*			62
20	61*			45*					62
21								81*	71
22		60*							58

TABLE 16 (Cont'd)

Equimax Rotated Factor Matrix for HIFAMS

Item	Factors								Communalities
	1	2	3	4	5	6	7	8	
23		51*							50
25						78*			65
26		51*		46*					57
27	40*			43*		31			53
30					70*				57
31			45*	43*					52
33			37*	47*					50
34				35*	55*				49
35		61*							53
36							39*	38*	45
37	37*								70
38					75*				65
39	33	33				34		31*	55
40	32	44*				40*			62
41		48*				44*			57
42				51*				33*	49
% Total Variance	8.5	8.5	7.4	7.1	7.1	7.1	6.8	5.2	Sum 20.79

Total variance accounted for 57.8%

* Items that serve to define the factor.

Note: The entries in the above matrix have been multiplied by a factor of 100 and rounded to the nearest whole number. Loadings less than 30 have dropped for simplification unless the item defines a factor.

F1: <u>What the school offers</u>

8. Working and studying conditions

10. Satisfaction with JHS

16. Satisfaction with courses offered

20. Perceived community satisfaction with the school

27. Satisfaction with JHS organization

29. School spirit

37. Satisfaction with equipment and facilities

13. Satisfaction with number of activities offered extra-curricularly.

F2: <u>The Teacher:</u> importance to the student

4. Are students treated fairly

15. Opinion of teachers

22. Satisfaction with the way in which JHS subjects are taught

23. Amount of help given by teachers

26. Satisfaction with marking system

35. Proficiency of teachers with respect to how well they know their subjects

40. Proficiency of teachers with respect to how good a job they do

41. Likeability of teachers, as persons.

F3: <u>Functionality of Student's Program</u>

2. Usefulness of work being taken (for future)

5. Chances of getting desired kind of job

6. Degree of interest of school work

7. *Frequency with which students get to study topics of interest to them*
12. *Degree of parent interest in student's work*
16. *Satisfaction with courses offered*
17. *Degree to which JHS work is the kind the student likes to do*
31. *Degree to which JHS will help in the enjoyment of and satisfaction with life*
33. *Degree to which the student is working hard on school work.*

F4: *Personal Teacher Characteristics*

15. *Opinion of teachers*
19. *Degree to which the teachers are interested in the student*
25. *Degree to which school personnel are approachable for help with personal problems*
40. *How good a job teachers do*
41. *Likeability of teachers, as persons.*

F5: *Teacher Mode Characteristics (TMC)*

7. *Frequency with which students get to study topics of interest to them*
18. *Frequency with which a variety of teaching methods are used*
21. *Frequency with which the student performs a large variety of activities in the classroom*

36. *Students learn about and practice the type of attitudes a scientist should have.*

F6: *The Student: Social Life*

9. *Is the student liked by other students*

30. *Satisfaction with social life in JHS*

34. *Opinion of boys and girls in JHS*

38. *Satisfaction with how well other people treat him.*

F7: *Proficiency of School*

6. *Degree of interest of school work*

13. *Satisfaction with number of activities offered extra-curricularly*

20. *Perceived community satisfaction with the school*

26. *Satisfaction with JHS organization*

31. *Degree to which JHS will help in the enjoyment of and satisfaction with life*

33. *Degree to which the student is working hard on school work*

42. *Proficiency of principal.*

F8: *TMC and Effectiveness of System*

10. *Satisfaction with JHS*

11. *Degree to which there are definite answers on conclusions to lab work*

14. *Frequency with which teacher gives correct answer right away when a science problem is presented*

15. *Opinion of teachers*

36. Students learn about and practice the type of attitudes a scientist should have

39. How good a job does your school do in educating its students?

The items which were removed from the analysis were: 1 - Identification of sex and 3, 24, 28 and 32, the TMC items. Table 16 identifies a relatively simple factor pattern which is consistent with the definition of construct validity presented earlier.

Student Attitude Towards Science (SATS). This test was developed by R. L. Hedley (1966) and was intended to measure student reaction to a course of study. The test consists of 72 items and checks student attitude towards:

a. Text material (13 items)

b. Course content (12 items)

c. Interest in the course (14 items)

d. Laboratory work (11 items)

e. Satisfaction of perceived needs (17 items)

f. Student involvement (5 items).

Student response is recorded on a five point Likert-type scale. Hedley found (1966, p. 84) "highly significant correlations between the sub-tests of SATS and the total score on SATS indicating that the instrument was measuring consistently". It is assumed Hedley is referring to internal consistency in making this statement but additional information and details on the test were not available and should be reported.

Factor analysis of this instrument did not support the subtest

classification and hence only the total test score is used in the main study.

Testing Program

All teachers selected to participate in the study were asked to: submit student I.Q. scores from cumulative records, complete the SLSI-T instrument, have an associate complete the SLSI-TA instrument, and submit a final grade 9 science mark. In addition teachers received a test booklet containing: 1) SLSI-S; 2) TOUS-Ew; 3) HIFAMS; 4) SATS; 5) TOUS-Jw and 6) TOSA (See Appendix F). Because of this large number of instruments and the time involved in writing them, teachers were given the option of having their students just write a given set of three criterion tests or have them write all the tests. Every student was instructed to respond to the SLSI-S instrument since it contained the predictor variables. The three compulsory tests were assigned to them according to one of the combinations in Table 17. This table illustrates all possible combinations of sets of three tests from the provided test booklet. Each test is included in six sets and each set assigned to 13 schools, which means each test should have been written in at least 78 schools. Table 18 gives the actual frequency of test writing based on results returned.

In addition eight randomly selected schools were requested to administer the STEP-Form 3A test in general science. Limited numbers of STEP tests made it impossible to test more than a few schools with this instrument. With the exception of STEP, tests had no time limits and were to be administered at teacher convenience. This was deemed reason-

TABLE 17

COMBINATIONS OF TESTS ADMINISTERED IN SCHOOLS

Test Sets									
A	B	C	D	E	F	G	H	I	J
1[a]	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	3	3	3	4
3	3	3	4	4	5	4	4	5	4
4	5	6	5	6	6	5	6	6	6

[a]Numbers refer to the tests as identified in Testing Program section and in the test booklet (See Appendix F).

TABLE 18

NUMBERS RESPONDING TO EACH INSTRUMENT

Instrument	Number of Teachers Represented	Number of Respondents From Population on Which Data Was Obtained		
		Students	Teachers	Teacher's Associate
SLSI-S	114	4479		
TOUS-Ew	87	3634		
HIFAMS	103	4259		
SATS	95	3892		
TOUS-Jw	71	2829		
TOSA	93	3425		
STEP	8	306		
I. Q.[a]	83	3121		
Science Mark	84	3121		
SLSI-TA	62			62
SLSI-T	109		109	

[a] I.Q. scores are from either the Lorge-Thorndike Intelligence Test or Otis Quick Scoring Mental Ability Test.

able in that the instruments elicited information and as such are more characteristic of power tests as opposed to speed or achievement tests.

Table 19 gives the sequence of the testing program. Appendix F contains the instructions and test booklet each student received as well as the instructions and questionnaires sent to the teachers and teacher's associates.

Summary of Testing Program. Data were collected using a randomized data collection system similar to that employed by Walberg (1969b) which resulted in a high percentage of students writing any given combination of tests. In the province's two largest centers, Calgary and Edmonton, correspondence with teachers was through the respective Research Directors. In Edmonton the selection basis appeared to be by volunteering whereas in Calgary only schools with heterogeneous classes were contacted.

Since testing was completed by mail and over an extended time period of up to four months, different teachers and students could be responding at different times of the year. Also, no control was exerted over the time allowed for test writing and considerable variance in length of testing periods probably occurred. As mentioned earlier, due to the type of tests this should be of little concern in the present study.

Of most concern is the lack of personal communication which could remove teacher suspicion regarding the function of the tests and indeed extra correspondence and phone calls were required in an attempt to convince teachers these tests had nothing to do with the recent removal of grade nine final exams by the Department of Education. Res-

TABLE 19

TESTING PROGRAM SEQUENCE

Dates (1973)	Materials Sent Out
January	Letters to Junior High School Principals with letters to Teachers of Grade Nine Science attached.
February	Letters of acceptance or rejection of teacher volunteers.
March, April & May	Letter requesting all tests or selected combination be written; sheet of Directions to teachers; class set of test booklets, directions to students and answer sheets.
April & May	STEP tests and letter of Directions. Letter requesting student I. Q.'s and estimated final science marks.
May	Letter requesting SLSI-T and SLSI-TA questionnaires be completed.
July	Summary of student scores and total group averages plus explanations sent to teachers.

ponses on the SLSI-T and SLSI-TA questionnaires are of concern because of this lack of personal contact and its effect on reliability and validity of the test scores. On the positive side the suspicion resulting from the Department of Education sponsoring the data collection may have helped in motivating the reasonably large number of requests for participation. Hence population values for the instruments could be obtained.

Data Processing

Responses to all instruments used in this study were made on the Department of Education General Purpose Answer Sheet 1 so that marking could be done optically. All marking was done at the University of Alberta using the 1230 Optical Scoring Service, and all data were punched on cards for subsequent analysis. Science Marks and I. Q. information obtained from the teachers were also punched onto cards for subsequent analysis.

All data were processed by computer programs developed by the Division of Educational Research Services (DERS) of the University of Alberta.

Paralleling the pilot study, teachers were classified into three groups on the basis of their TMC scores as indicated by each rating group: their students, the teacher himself, and a teacher's associate. In each of the three cases the teachers who had the lowest TMC score were compared with the teachers who had the highest TMC scores (See Table 20) to show significant differences of TMC scores. Subsequently students from each set of High and Low Treatment Groups were compared on

TABLE 20

SEPARATION OF TEACHERS INTO TREATMENT GROUPS

	Teacher Rating Score		
	Student	Teacher	Teacher's Associate
TMC	High	High	High
Scores	Medium	Medium	Medium
	Low	Low	Low

each of the criterion measures to ascertain which separation method resulted in greatest predictive ability.

The high scores in each ranking were compared with the low scores in the same ranking method by analysis of variance to test for significant differences.

The comparison of students in high and low groups in each case was made by using analysis of variance and analysis of covariance. The analysis of covariance took I. Q. into consideration as the covariate. The results of these tests will be compared with the pilot study and Walberg's (1969b, p. 444) findings as to whether or not the student's perception of the learning environment is significant for predictive purposes. The method used in the one-way analysis of variance is as described by Ferguson (1966, pp. 281-291).

Three sets of means and standard deviations are reported for each instrument: a set using the number of teachers whose students produced useable data (Group 1) as the unit of comparison (teacher-classroom), a set using the total number of students (Group 2) responding to each instrument (population), and a set using the number of students responding in all instruments except STEP (sample) (Group 3). (Since schools sending in data for all tests did not always have all students answer all instruments, the numbers in Group 3 are not identical for each instrument.) Since most of the analysis centers on the student as the unit, differences between Groups 2 and 3 are important for generalizability of findings. These data are reported later in Tables 23, 24 and 25 and in summary form in Appendix H.

Because of the size of the original sample (Group 2) it can be taken as representative of the population to a high degree. Using the Tchebycheff inequality (Hays, 1963, pp. 188, 205):

$$\text{prob. } (|M - \mu l < .1\sigma) \geq 1 - \frac{\sigma^2}{N(.1\sigma)^2}$$

replacing the right hand side by 0.95 and solving for N it can be seen that 2000 is the largest number of cases the experimenter is required to observe to have at least a 95% chance that the sample value is within 0.1 standard deviation of the true mean

$$1 - \frac{1}{N(.01)} = 0.95$$

$$\frac{1}{N} = 0.0005$$

$$N = 2000.$$

Using numbers from Table 24, Group 2, (also see Appendix H) the probability is as high as 0.98 that, with the exception of STEP, the means observed are within 0.1 standard deviation of the population means. As such the data in Table 24 can be considered to be representative of the true population values of these parameters and Group 3 then can be taken as one sample of the population.

The first phase of the study, then, is concerned with testing the predictive ability of the three sources of TMC scores. The next phase of the analysis, using data from Group 3, consists of classifying students into three groups using their Desire (D) scores from SLSI-S. These scores are indicative of the student's desire for a high inquiry-oriented teacher or science learning situation (See Table 21).

The low and high groups were compared on all criterion scores by means of analysis of variance and analysis of covariance with I. Q.

TABLE 21

SEPARATION OF STUDENTS ON THE BASIS OF D-SCORES

(N = 482)

	Level of Inquiry-Orientedness Desired in the Science Learning Situation		
	Low	Medium	High
Number of Students	161	160	161

as covariate in the case of the analysis of covariance.

Students were subsequently ranked by the degree of being matched to their environment. This was done by ranking students in the low-desire and high-desire groups with respect to their discrepancy (D-A) scores. Thus each group could be split into students who perceived that they were getting their desired mode of instruction and those who weren't. The top and bottom one-third of each group was retained for further analysis, hence four groups result as indicated in Table 22.

Data for four groups in Table 22 were analyzed via analysis of variance and analysis of covariance indicate differences in A, D and D-A scores. Subsequently these groups were compared using Scheffe Multiple Comparisons to indicate the significance of the pair-wise comparisons. Finally, all four groups, those matched or not matched with their desire for a high or low inquiry-oriented science learning situation, were compared by analysis of variance and analysis of covariance on all criterion measures.

TABLE 22

MATCHING OF STUDENTS TO THEIR SCIENCE LEARNING SITUATION

(N = 212)

		Score Characteristics		
Group	Description	Source	D - A	N
1	Want low inquiry Are getting low inquiry	Low D Low A	small	54
2	Want low inquiry Are not getting	Low D $D \neq A$	large	52
3	Want high inquiry Are getting high inquiry	High D High A	small	54
4	Want high inquiry Are not getting	High D $D \neq A$	large	52

CHAPTER IV

RESULTS

In this chapter the results and their analysis are presented. First the predictor and criterion test data are given as yielded by the three sources: the classroom, the individual student and a selected sample of students. Following the tabulation of this base data, correlations between pairs of predictor measures and then pairs of criterion measures are presented. Subsequently each of the hypotheses posed in Chapter I is tested.

Data Collected

Tables 23, 24 and 25 give the means, standard deviations and number of respondents for each unit from which data are reported: the teacher's classroom, the student population, and the sample students.

A breakdown of the number of individuals responding to each test from each sample class appears in Table 26. This sample of six classes represents a wide range of teaching situations from small rural areas to large urban centers. Also, two of the teachers come from the same school. The double circled school sites in Appendix E indicate the geographic distribution of the sample schools. Table 26 also shows the reason for an unequal number of students representing each measure: not all students wrote all instruments in each school.

TABLE 23

MEASUREMENT STATISTICS USING TEACHER-CLASSROOM AVERAGES

(Group 1)

Instruments	Mean	Standard Deviation	Number of Teacher-Classrooms
Predictor Measures			
SLSI-TMC	132.26	9.45	110
SLSI-A	62.95	5.52	110
SLSI-D	56.46	2.35	110
SLSI-T	130.77	14.44	64
SLSI-TA	132.69	14.17	36
Criterion Measures			
HIFAMS	129.43	6.34	105
TOSA	15.74	8.61	84
TOSA-CCS	6.80	1.10	84
TOSA-ICS	7.92	1.23	84
SCIENCE MARK	59.36	5.55	79
I. Q.	105.87	5.03	72
TOUS-Ew	20.51	1.90	83
TOUS-Jw	22.39	3.61	68
SATS	205.09	10.13	91

TABLE 24

MEASUREMENT STATISTICS USING INDIVIDUAL STUDENT'S SCORES IN THE TOTAL POPULATION

(Group 2)

Instruments	Mean	Standard Deviation	Number of Students
Predictor Measures			
SLSI-TMC	131.62	18.40	4479
SLSI-A	62.95	10.17	4479
SLSI-D	56.28	7.14	4479
SLSI-T[a]	(130.77)	(14.44)	(64 class-rooms)
SLSI-TA[a]	(132.69)	(14.17)	(36 class-rooms)
Criterion Measures			
HIFAMS	129.69	13.80	4259
TOSA	14.94	4.88	3425
TOSA-CCS	6.94	2.78	3425
TOSA-ICS	7.99	2.94	3425
SCIENCE MARK	59.00	14.98	3121
I.Q.	105.64	12.46	3121
TOUS-Ew	20.57	5.30	3634
TOUS-Jw	22.47	6.78	2829
SATS	205.57	24.42	3892
STEP	38.82	8.56	465

(See Appendix J for Scores for all tests and sub-tests)

[a]SLSI-T and SLSI-TA were only responded to by teachers and teacher's associates, respectively.

TABLE 25

MEASUREMENT STATISTICS USING INDIVIDUAL STUDENT'S SCORES IN THE SAMPLE

(Group 3)

Instruments	Mean	Standard Deviation	Number of Students
Predictor Measures			
SLSI-TMC	128.59	16.60	482
SLSI-A	61.62	9.86	482
SLSI-D	56.75	7.18	482
SLSI-T[a]	(133.00)	(8.88)	(6)
SLSI-TA[a]	(129.20)	(9.98)	(6)
Criterion Measures			
HIFAMS	132.23	12.45	471
TOSA	15.88	4.49	404
TOSA-CCS	6.50	2.63	404
TOSA-ICS	8.37	2.74	404
SCIENCE MARK	61.41	13.95	482
I.Q.	106.91	12.08	457
TOUS-Ew	21.46	4.88	473
TOUS-Jw	24.12	6.35	439
SATS	206.50	24.83	477
STEP	38.92	8.55	306

(See Appendix J for scores for all tests and sub-tests)

[a]SLSI-T and SLSI-TA scores are those reported by each teacher or teacher's associate, respectively.

TABLE 26

NUMBER OF RESPONDENTS TO INSTRUMENTS

IN THE SAMPLE CLASSES

Instruments	Teachers						Total
	A	B	C	D	E	F	
SLSI-T[a]	1	1	1	1	1	1	6
SLSI-TA[a]	1	1	1	1	1	1	6
SLSI-S	48	57	32	94	210	41	482
HIFAMS	47	50	31	94	208	41	471
TOSA	40	53	29	94	147	41	404
SCIENCE MARK	48	57	32	94	210	41	482
I. Q.	47	55	31	93	193	38	457
TOUS-Ew	44	53	32	95	210	39	473
TOUS-Jw	45	55	31	95	173	40	439
SATS	45	56	31	94	210	41	477
STEP		56			211	39	306
Total Possible Number of Respondents to Each Student Instrument	48	57	33	95	211	41	482

[a]SLSI-T and SLSI-TA scores are those reported by each teacher or teacher's associate, respectively.

Correlations

Data from Table 25 are used in the following calculations of Pearson Product Moment Correlations and the probabilities that they are zero.

Predictor Scores

Pearson product moment correlations between the various pairs of scores given by the SLSI-S instrument were given earlier in Table 14 and discussed at that time.

Criterion Measures

Table 27 gives the correlations between pairs of criterion measures.

An aim of the study is to classify students in various ways by using the predictor measures and then to check results of these classifications in affective and cognitive domains (see Figure 2). The correlations among the criterion measures indicate that somewhat distinct areas are being measured. STEP, I. Q., Science Mark and TOUS may all be described as primarily in the cognitive domain in that they show relatively high inter-correlations from 0.47 to 0.66. On the other hand, HIFAMS described as a measure in the affective domain correlates to a very small degree with these measures. The largest correlation between HIFAMS and the cognitive group of instruments is 0.23 indicating it may be measuring a different domain. TOSA seems to be somewhere between HIFAMS and the former group but probably is measuring more in the cognitive domain than the affective domain. The status of SATS is

TABLE 27

CORRELATIONS BETWEEN CRITERION MEASURES FOR SAMPLE STUDENTS

AND ASSOCIATED PROBABILITIES THAT $r=0^{a}$

	STEP	I.Q.	SCIENCE MARK	TOUS-Ew	TOUS-Jw	TOSA	TOSA-CCS	TOSA-ICS	HIFAMS	SATS
STEP										
I. Q.	0.60 (<0.001)									
SCIENCE MARK	0.66 (<0.001)	0.49 (<0.001)								
TOUS-Ew	0.57 (<0.001)	0.51 (<0.001)	0.47 (<0.001)							
TOUS-Jw	0.54 (<0.001)	0.49 (<0.001)	0.47 (<0.001)	0.66 (<0.001)						
TOSA	0.45 (<0.001)	0.37 (<0.001)	0.37 (<0.001)	0.50 (<0.001)	0.53 (<0.001)					
TOSA-CCS	0.34 (<0.001)	0.37 (<0.001)	0.35 (<0.001)	0.43 (<0.001)	0.49 (<0.001)	0.83 (<0.001)				
TOSA-ICS	0.40 (<0.001)	0.24 (<0.001)	0.28 (<0.001)	0.40 (<0.001)	0.40 (<0.001)	0.83 (<0.001)	0.40 (<0.001)			

TABLE 27 (Cont'd)

Correlations Between .... Probabilities That $r=0$[a]

	STEP	I.Q.	SCIENCE MARK	TOUS-Ew	TOUS-Jw	TOSA	TOSA-CCS	TOSA-ICS	HIFAMS	SATS
HIFAMS	0.13 (0.02)	0.08 (0.13)	0.23 (<0.001)	0.20 (<0.001)	0.19 (<0.001)	0.14 (0.01)	0.13 (0.01)	0.12 (0.02)		
SATS	-0.15 (0.01)	-0.09 (0.06)	-0.28 (<0.001)	-0.14 (<0.001)	-0.12 (0.01)	-0.13 (0.01)	-0.14 (0.01)	-0.07 (0.16)	-0.60 (<0.001)	

[a]Probabilities that correlations are zero are given in parentheses below each correlation. (The number of degrees of freedom associated with each correlation can be obtained from Table 25 and equals N-2.)

of question in that its highest correlation is with HIFAMS but it is negative. In fact, SATS correlates negatively with all other measures. It is suspected that several variables including the length of SATS affected student responses. The correlations of SATS and the other measures indicate it is very questionable with respect to concurrent validity. It is doubtful that the total test score can be meaningfully interpreted and will, to a large degree, be utilized in a minor way in the rest of the present study.

The results of these correlations appear to support an objective of the study: to measure student attributes in not just the cognitive domain but in the affective domain as well. In addition, instruments such as TOUS and TOSA expand the areas traditionally considered in the cognitive domain by exploring students knowledge of the nature of science and scientists.

Tests of Stated Hypotheses

Each of the hypotheses posed in Chapter I is considered in this section.

Hypotheses are tested either by analysis of variance, or analysis of variance and analysis of covariance using I.Q. as the covariate. In certain cases it is desirable to know if differences between criterion means remain after a statistical adjustment has been made for the effects of the covariate. These methods use the criterion that the probability of rejecting the null hypothesis when it is true should not exceed 0.01 or 0.05 for any of the comparisons.

Assumptions Underlying the Analysis of Variance

1. The sampling within groups should be random, such that the distributions of the variables in the populations from which the samples are drawn are normal. A problem exists here when the samples are fairly small; it is usually not possible to "rigorously demonstrate lack of normality in data" (Ferguson, 1966, p. 294). The results of departure from normality frequently make the results appear somewhat more significant than they are. In interpreting these results a more rigorous level of confidence than usual may be employed.
2. The variances from within the various groups must be approximately equal, that is, there is homogeneity of variance. Since the within-groups mean square is commonly the denominator of F-ratios, it must be a reasonably accurate approximation of the population variance in each case.
3. The effects of various factors on the total variation are additive. Deviations between and within groups are assumed to be independent and additive to give the total variance. (Ferguson, 1966, pp. 294-295; Guilford, 1965, p. 274).

The following hypotheses can be tested using the analysis of variance procedure provided the above assumptions are considered. Where small cell sizes exist the level of rejection of the null hypotheses are particularly noted and the degree of homogeneity of variance is reported.

Hypothesis 1 (H_1):

There is no significant difference between TMC scores for

teachers classified as high inquiry-oriented and teachers classified as low inquiry-oriented as indicated by each of the rating methods: teacher, student, teacher's associate.

To test this hypothesis classrooms were separated into treatment groups as indicated in Table 20, and pairs of means tested by analysis of variance. The data in Table 28 resulted.

The data pass the homogeneity of variance test and significant differences ($p < .001$) occur in all three comparisons; Hypothesis H_1 is rejected and it thus seems warranted to use each of the three methods of separating classrooms for further comparisons.

Hypothesis 2 (H_2):

When teachers are ranked as high inquiry or low inquiry-oriented by their students, themselves or an associate there are no significant differences between the students of the two resultant groups in each classification as indicated by the criterion measures: HIFAMS, TOSA, Science Mark, I. Q., TOUS-Ew, TOUS-Jw, SATS.

To test this hypothesis classrooms were separated into treatment groups as indicated in Table 20 and students in the high inquiry-oriented groups were compared with students in the low inquiry-oriented groups on each of the criterion measures by analysis of variance. The results of this analysis appear in Table 29. A summary of the significant differences at the 0.05 or 0.01 level is given in Table 30.

Very few significant differences were observed: HIFAMS scores were significantly different when the rating of TMC was by the student or the teacher and in each case students from teachers classified as

TABLE 28

COMPARISON OF THE TMC SCORES FROM HIGH INQUIRY AND LOW INQUIRY-ORIENTED GROUPS AS RATED BY STUDENTS, TEACHERS AND TEACHER'S ASSOCIATES

Rating Group	Treatment Group Description	Mean	Variance	N	df	F-Ratio	p
Student	Low Inquiry	121.28	13.58	21	(1,46)	224.35	<0.001
	High Inquiry	143.34	9.54	27			
Teacher	Low Inquiry	115.86	43.98	14	(1,25)	117.64	<0.001
	High Inquiry	145.38	56.43	13			
Teacher's Associate	Low Inquiry	118.33	86.51	9	(1,15)	51.43	<0.001
	High Inquiry	145.63	32.55	8			

TABLE 29

DIFFERENCES IN SCORES OBTAINED BETWEEN STUDENTS OF TEACHERS CLASSIFIED AS LOW IN INQUIRY-ORIENTEDNESS (L) AND STUDENTS OF TEACHERS CLASSIFIED AS HIGH IN INQUIRY-ORIENTEDNESS (H) FOR EACH OF THREE RATING METHODS

Criterion Measure		Classification Method					
		Student		Teacher		Teacher's Associate	
		L	H	L	H	L	H
HIFAMS	Mean	125.10	132.95	125.83	132.63	132.22	133.66
	Var.	65.22	18.05	26.91	34.48	30.85	14.03
	N	20	25	13	12	8	7
	F-Ratio	15.76		9.41		0.33	
	p	<0.001		0.005		0.57	
	df	(1,43)		(1,23)		(1,13)	
TOSA	Mean	14.68	14.91	15.00	25.12	16.20	15.10
	Var.	4.54	2.99	3.73	4.16	2.08	2.51
	N	17	18	12	8	6	5
	F-Ratio	0.12		1.71		1.46	
	p	0.73		0.21		0.26	
	df	(1,33)		(1,18)		(1,9)	

TABLE 29 (Cont'd)

Differences in Scores .... Three Rating Methods

Criterion Measure		Classification Method					
		Student		Teacher		Teacher's Associate	
		L	H	L	H	L	H
TOSA-CCS	Mean	6.99	6.80	7.05	6.31	7.64	6.98
	Var.	0.83	0.61	0.79	3.28	0.83	0.30
	N	17	18	12	8	6	5
	F-Ratio	0.46		1.49		2.06	
	p	0.50		0.24		0.18	
	df	(1,33)		(1,18)		(1,9)	
TOSA-ICS	Mean	7.71	8.09	7.96	7.94	8.55	8.10
	Var.	1.86	1.01	1.38	2.52	0.53	1.21
	N	17	18	12	8	6	5
	F-Ratio	0.93		0.00		0.67	
	p	0.34		0.97		0.44	
	df	(1,33)		(1,18)		(1,9)	
SCIENCE MARK	Mean	59.43	60.83	58.51	58.97	58.69	58.81
	Var.	27.19	24.95	25.14	42.08	19.54	61.52
	N	20	20	12	10	7	7
	F-Ratio	0.75		0.04		0.00	
	p	0.39		0.85		0.97	
	df	(1,38)		(1,20)		(1,12)	

TABLE 29 (Cont'd)

Differences in Scores .... Three Rating Methods

Criterion Measure		Classification Method					
		Student		Teacher		Teacher's Associate	
		L	H	L	H	L	H
I. Q.	Mean	103.96	107.24	104.64	106.11	105.10	105.11
	Var.	16.08	24.92	9.14	19.53	12.98	27.08
	N	21	27	14	13	9	8
	F-Ratio	6.02		1.03		0.000	
	p	0.018		0.32		0.995	
	df	(1,46)		(1,25)		(1,15)	
TOUS-Ew	Mean	20.44	20.98	20.61	20.53	21.18	20.59
	Var.	2.74	2.80	2.09	3.34	1.48	2.27
	N	17	19	14	13	9	8
	F-Ratio	0.93		0.02		0.80	
	p	0.34		0.90		0.39	
	df	(1,34)		(1,25)		(1,15)	
TOUS-Jw	Mean	21.95	23.18	22.10	21.30	23.13	22.58
	Var.	9.10	3.87	7.94	7.82	4.42	7.14
	N	11	13	10	8	6	5
	F-Ratio	1.45		0.23		0.15	
	p	0.24		0.64		0.71	
	df	(1,22)		(1,12)		(1,9)	

TABLE 29 (Cont'd)

Differences in Scores .... Three Rating Methods

Criterion Measure		Classification Method					
		Student		Teacher		Teacher's Associate	
		L	H	L	H	L	H
SATS	Mean	211.70	197.48	206.10	204.11	204.46	196.12
	Var.	83.50	32.30	107.53	42.65	89.97	83.16
	N	15	19	10	9	8	5
	F-Ratio	30.87		0.24		2.405	
	p	<0.001		0.63		0.15	
	df	(1,32)		(1,17)		(1,11)	

TABLE 30

SUMMARY OF SIGNIFICANT DIFFERENCES BETWEEN STUDENTS OF TEACHERS CLASSIFIED AS LOW INQUIRY-ORIENTED AND STUDENTS OF TEACHERS CLASSIFIED AS HIGH INQUIRY-ORIENTED FOR EACH OF THE THREE RATING METHODS

Criterion Measure	Rating Method		
	Student	Teacher	Teacher's Associate
HIFAMS	**	**	
TOSA TOTAL			
TOSA-CCS			
TOSA-ICS			
SCIENCE MARK			
I. Q.	*		
TOUS-Ew			
TOUS-Jw			
SATS	**		

** Indicates significance at the .01 level.
* Indicates significance at the .05 level.

high inquiry-oriented scored higher than students from teachers classified as low inquiry-oriented. SATS scores for students from teachers with low TMC scores were significantly better than those from teachers with high TMC scores when rated by students. I. Q. differs only under the student classification method and then only at the 0.05 level and in favor of the students whose teachers obtained higher TMC scores.

These results differ considerably from those obtained in the pilot study in that few significant differences were found here. It still appears, however, that the student classification of the classroom may be the best for predictive purposes in so far as student cognitive and affective behaviors are concerned but that the teacher's associate is of little value in this regard. As in the pilot study classroom averages were used for student assignment of TMC scores to their teacher. It is tenable that utilization of classroom average TMC scores is not the most desirable methodology for relating TMC to student behaviors but that the individual student within the classroom should be considered.

The hypothesis that neither students, teachers nor teacher's associates can be used to predict relationships between TMC and student behaviors is rejected only for student and teacher classification methods and then only for predicting scores on HIFAMS, I. Q. and SATS using the student rating method and HIFAMS using the teacher rating.

Hypothesis 3 (H_3):

H_3a. When students are classified as desiring either a high inquiry-oriented science learning situation or a low inquiry-oriented science learning situation the two resultant groups show no significant differences in their performance on the cirterion measures: HIFAMS,

TOSA, Science Mark, TOUS-Ew, TOUS-Jw, SATS or STEP.

H_3b. When students are classified as desiring either a high inquiry-oriented science learning situation or a low inquiry-oriented science learning situation the two resultant groups will show no significant difference in their performance on the criterion measures: HIFAMS, TOSA, Science Mark, TOUS-Ew, TOUS-Jw, SATS, or STEP, when I.Q. is used as a covariate.

Table 31 gives the SLSI and I.Q. scores for students in each of the two groups: desire for a high inquiry-oriented science learning situation (Group H) and desire for a low inquiry-oriented science learning situation (Group L). It appears that I.Q. scores for the two groups are significantly different indicating the necessity for testing for this difference and the utilization of analysis of covariance with I.Q. as covariate.

Table 32 shows the distribution of students from each group in each classroom. The reader is reminded that the total sample of 482 students was ranked by their D-scores independently of their classrooms and the top and bottom thirds (Table 21) were utilized to test this hypothesis. Hence the summary presented in Table 35 is an indication of the degree to which each classroom contributed students to each group: desire for a high inquiry-oriented classroom or a desire for a low inquiry-oriented classroom. It appears that about half the students in each classroom desire a low inquiry-oriented approach and half a high inquiry-oriented approach. Since these students represent the top and bottom thirds of students with respect to desire for inquiry-orientedness, it seems reasonable to assume heterogeneous classrooms contain students desiring a continuum of inquiry-orientedness.

TABLE 31

SLSI AND I.Q. SCORES OF STUDENTS RANKED BY D-SCORES

GROUP	LEVEL OF INQUIRY ORIENTEDNESS DESIRED	N	MEAN D-SCORE	RANGE OF D-SCORES	MEAN A-SCORE	MEAN D-A	MEAN I.Q.
L	Low	160	3.07	2.13 to 3.38	2.78	0.29	104.60
H	High	161	4.03	3.75 to 4.81	3.08	0.95	110.28

TABLE 32

NUMBER OF STUDENTS OF EACH TEACHER WHO DESIRE HIGH INQUIRY-ORIENTEDNESS (H) AND LOW INQUIRY-ORIENTEDNESS (L)

	GROUP	
TEACHER	H	L
A	20	9
B	19	24
C	18	11
D	27	29
E	64	76
F	14	12
TOTAL	162	161

In addition to the total test scores from the criterion instruments the analysis also included subtests of HIFAMS and TOSA yielding 15 criterion measures in all. The results of analysis of variance and analysis of covariance are presented in Tables 33 and 34 as well as the Bartlett-Box tests of homogeneity of group variances. With respect to homogeneity of variance only SATS need be suspect under the analysis of variance procedure. Seven of the instruments show lack of homogeneity of variance at the 0.02 level under the analysis of covariance treatment. The 0.02 level may still be acceptable since, as Winer states, this test for homogeneity of variance is "oversensitive to departures from normality" (1962, p. 96).

A summary of Tables 33 and 34 is presented in Table 35. In looking at test scores the students with the high D-scores (that is, those who prefer a high inquiry-oriented science learning situation) had higher marks on all criterion measures except SATS. When tested by analysis of variance, nine of these 15 differences were significant at the 0.01 level and two at the 0.05 level. When I. Q. was used as covariate five of the significant differences become non-significant and two non-significant differences become significant. Analysis of covariance did not change the rank of any set of scores. That is, students who desire a high inquiry-oriented science learning situation perform significantly better on eleven of the fifteen criterion measures when compared with students who desire a low inquiry-oriented learning situation. I. Q. used as covariate did not change the rank of the two groups but did change which scores were significant. The criterion measures

TABLE 33

ANALYSIS OF VARIANCE ON CRITERION MEASURES OF STUDENTS CLASSIFIED AS DESIRING A HIGH INQUIRY-ORIENTED SCIENCE LEARNING SITUATION AS COMPARED WITH STUDENTS CLASSIFIED AS DESIRING A LOW INQUIRY-ORIENTED SCIENCE LEARNING SITUATION[a]

CRITERION MEASURE	SIGNIFICANCE TESTS: ANOVA					BARTLETT-BOX TESTS OF HOMOGENEITY OF GROUP VARIANCES	
	SOURCE						
	S.S.	D.F.	M.S.	F-RATIO	PROB.	CHISQ	PROB.
HIFAMS TOTAL							
Effects	3527.61	1.	3527.61	19.47	<0.001	0.12	0.73
Errors	55958.00	309.	181.09				
F1 SCHOOL OFFERS							
Effects	27.05	1.	27.05	1.76	0.18	0.14	0.71
Errors	4735.31	309.	15.32				
F2 TEACHER IMPORTANCE							
Effects	423.85	1.	423.85	24.99	<0.001	1.61	0.20
Errors	5239.93	309.	16.95				
F3 PROGRAM IMPORTANCE							
Effects	334.49	1.	334.49	21.40	<0.001	0.05	0.82
Errors	4829.12	309.	15.62				

TABLE 33 (Cont'd)

Analysis of Variance .... Science Learning Situation

CRITERION MEASURE	SIGNIFICANCE TESTS: ANOVA — SOURCE					BARTLETT-BOX TESTS OF HOMOGENEITY OF GROUP VARIANCES	
	S.S.	D.F.	M.S.	F-RATIO	PROB.	CHISQ	PROB.
F4 TEACHER CHARACTERISTICS							
Effects	159.87	1.	189.87	19.73	<0.001	0.89	0.34
Errors	2503.12	309.	8.10				
F5 TMC							
Effects	17.32	1.	17.32	2.32	0.13	0.17	0.68
Errors	2305.81	309.	7.46				
F6 SOCIAL LIFE							
Effects	31.27	1.	31.27	7.17	0.008	3.52	0.06
Errors	1347.71	309.	4.36				
SATS							
Effects	21501.27	1.	21501.27	371.8	<0.001	9.87	0.002
Errors	182154.00	315.	578.26				

TABLE 33 (Cont'd)

Analysis of Variance .... Science Learning Situation

CRITERION MEASURE	SIGNIFICANCE TESTS: ANOVA					BARTLETT-BOX TESTS OF HOMOGENEITY OF GROUP VARIANCES	
	SOURCE						
	S.S.	D.F.	M.S.	F-RATIO	PROB.	CHISQ	PROB.
SCIENCE MARK							
Effects	5365.23	1.	5365.23	29.73	<0.001	1.47	0.23
Errors	56830.00	315.	180.41				
STEP							
Effects	362.67	1.	362.67	4.98	0.03	0.34	0.56
Errors	0928.81	124.	72.81				
TOSA TOTAL							
Effects	44.53	1.	44.53	2.53	0.11	0.02	0.89
Errors	2179.64	124.	17.57				
TOSA-CCS							
Effects	38.13	1.	38.13	6.68	0.01	0.10	0.75
Errors	707.14	124.	5.79				

TABLE 33 (Cont'd)

Analysis of Variance .... Science Learning Situation

CRITERION MEASURE	SIGNIFICANCE TESTS: ANOVA					BARTLETT-BOX TESTS OF HOMOGENEITY OF GROUP VARIANCES	
	SOURCE						
	S.S.	D.F.	M.S.	F-RATIO	PROB.	CHISQ	PROB.
TOSA-ICS							
Effects	1.67	1.	1.67	0.25	0.61	1.13	0.29
Errors	811.70	124.	6.54				
TOUS-EW							
Effects	197.70	1.	197.70	9.31	0.003	0.13	0.72
Errors	2634.05	124.	21.24				
TOUS-Jw							
Effects	171.28	1.	171.28	4.41	0.04	1.52	0.22
Errors	4811.75	124.	38.80				

[a] Refer to Table 35 for means.

TABLE 34

ANALYSIS OF VARIANCE ON CRITERION MEASURES OF STUDENTS CLASSIFIED AS DESIRING A HIGH INQUIRY-ORIENTED SCIENCE LEARNING SITUATION AS COMPARED WITH STUDENTS CLASSIFIED AS DESIRING A LOW INQUIRY-ORIENTED SCIENCE LEARNING SITUATION WITH I. Q. AS COVARIATE

CRITERION MEASURE	SIGNIFICANCE TESTS: ANCOVA					BARTLETT-BOX TESTS OF HOMOGENEITY OF GROUP VARIANCES	
	SOURCE						
	S.S.	D.F.	M.S.	F-RATIO	PROB.	CHISQ	PROB.
HIFAMS TOTAL							
Effects	3292.52	1.	3292.52	18.32	<0.001	1.12	0.29
Cov 1	10.95	1.	10.95	0.06	0.81		
Errors	51741.00	288.	179.65				
F1 SCHOOL OFFERS							
Effects	13.10	1.	13.10	0.84	0.36	1.17	0.28
Cov 1	14.83	1.	14.83	0.95	0.33		
Errors	4467.18	288.	15.51				
F2 TEACHER IMPORTANCE							
Effects	347.28	1.	347.28	20.08	<0.001	4.02	0.05
Cov 1	3.19	1.	3.19	0.18	0.67		
Errors	4978.50	288.	17.28	0.18			

TABLE 34 (Cont'd)

Analysis of Variance .... I. Q. as Covariate

CRITERION MEASURE	SIGNIFICANCE TESTS: ANCOVA					BARTLETT-BOX TESTS OF HOMOGENEITY OF GROUP VARIANCES	
	SOURCE						
	S.S.	D.F.	M.S.	F-RATIO	PROB.	CHISQ	PROB.
F3 PROGRAM IMPORTANCE							
Effects	302.06	1.	302.07	19.62	<0.001	1.09	0.30
Cov 1	8.29	1.	8.29	0.53	0.46		
Errors	4432.87	288.	15.39				
F4 TEACHER CHARACTER-ISTICS							
Effects	158.05	1.	158.05	20.51	<0.001	2.23	0.14
Cov 1	4.55	1.	4.55	0.59	0.44		
Errors	2118.51	288.	7.70				
F5 TMC							
Effects	35.46	1.	35.46	4.80	0.03	1.51	0.22
Cov 1	32.61	1.	32.61	4.41	0.01		
Errors	2125.50	288.	7.38				

TABLE 34 (Cont'd)

Analysis of Variance .... I. Q. as Covariate

CRITERION MEASURE	SIGNIFICANCE TESTS: ANCOVA — SOURCE					BARTLETT-BOX TESTS OF HOMOGENEITY OF GROUP VARIANCES	
	S.S.	D.F.	M.S.	F-RATIO	PROB.	CHISQ	PROB.
F6 SOCIAL LIFE							
Effects	20.77	1.	20.77	4.69	0.31	5.24	0.02
Cov 1	8.03	1.	8.03	1.81	0.18		
Errors	1275.24	288.	4.42				
SATS							
Effects	635411.93	1.	635411.93	5.47	0.02	0.58	0.44
Cov 1	139156.12	1.	139156.12	1.19	0.27		
Errors	--	305.	116080.75				
SCIENCE MARK							
Effects	2537.32	1.	2537.32	3.14	0.08	0.57	0.45
Cov 1	19.25	1.	19.25	0.02	0.08		
Errors	245899.37	305.	806.22				
STEP							
Effects	1140.74	1.	1140.74	1.19	0.28	5.68	0.02
Cov 1	43.68	1.	43.68	0.04	0.83		
Errors	116072.06	122.	951.41				

TABLE 34 (Cont'd)

Analysis of Variance .... I. Q. as Covariate

CRITERION MEASURE	SIGNIFICANCE TESTS: ANCOVA					BARTLETT-BOX TESTS OF HOMOGENEITY OF GROUP VARIANCES	
	SOURCE						
	S.S.	D.F.	M.S.	F-RATIO	PROB.	CHISQ	PROB.
TOSA TOTAL							
Effects	1262.87	1.	1262.87	1.47	0.23	5.29	0.002
Cov 1	119.16	1.	119.16	0.13	0.71		
Errors	104234.62	122.	854.38				
TOSA-CCS							
Effects	60.66	1.	60.66	0.06	0.80	5.11	0.02
Cov 1	285.37	1.	285.37	0.30	0.58		
Errors	113308.93	122.	928.76				
TOSA-ICS							
Effects	5412.43	1.	5412.43	5.51	0.02	5.55	0.02
Cov 1	4.63	1.	4.63	0.00	0.95		
Errors	119799.50	122.	981.96				

TABLE 34 (Cont'd)

Analysis of Variance .... I. Q. as Covariate

CRITERION MEASURE	SIGNIFICANCE TESTS: ANCOVA					BARTLETT-BOX TESTS OF HOMOGENEITY OF GROUP VARIANCES	
	SOURCE						
	S.S.	D.F.	M.S.	F-RATIO	PROB.	CHISQ	PROB.
TOUS-Ew							
Effects	209.23	1.	209.23	0.23	0.63	5.45	0.02
Cov 1	2038.27	1.	2038.27	2.33	0.13		
Errors	106409.00	122.	872.20				
TOUS-Jw							
Effects	1477.17	1.	1477.17	1.52	0.22	5.14	0.02
Cov 1	3229.86	1.	3229.86	3.33	0.07		
Errors	118262.06	122.	969.36				

TABLE 35

COMPARISON OF STUDENTS WITH HIGH D-SCORES (H) AND STUDENTS

WITH LOW D-SCORES (L): I.Q. USED AS COVARIATE

CRITERION MEASURE	RANK OF GROUP[a]	LEVEL OF SIGNIFICANT DIFFERENCE[b]			MEANS BEFORE COVARIATE	
		NSD	.05	.01	H	L
HIFAMS TOTAL	H > L			XO	138.8	129.1
F1:[c] SCHOOL OFFERS	H > L	XO			27.0	26.4
F2: TEACHER IMPORTANCE	H > L			XO	29.2	26.9
F3: PROGRAM IMPORTANCE	H > L			XO	31.6	29.5
F4: TEACHER CHARACTER-ISTICS	H > L			XO	16.7	15.3
F5: TMC	H > L	O	X		10.6	10.2
F6: SOCIAL LIFE	H > L		X	O	13.9	13.3
SATS	L > H		X	O	198.8	215.3
SCIENCE MARK	H > L	X		O	65.8	27.6

TABLE 35 (Cont'd)

Comparison of Students .... I.Q. Used as Covariate

CRITERION MEASURE	RANK OF GROUP	LEVEL OF SIGNIFICANT DIFFERENCE			MEANS BEFORE COVARIATE	
		NSD	.05	.01	H	L
STEP	H > L	X	O		41.2	37.8
TOSA	H > L	XO			16.3	15.1
TOSA-CCS	H > L	X		O	7.9	6.8
TOSA-ICS	H > L	O	X		8.4	8.1
TOUS-Ew	H > L	X		O	23.2	20.1
TOUS-Jw	H > L	X	O		25.9	23.6

[a] This column indicates the group which performs best; the group with the highest score is listed first.

[b] O = level before covariate; X = level after covariate.

[c] Factors are described in Chapter III.

which no longer showed significant differences for the two groups when I. Q. was used as covariate appear to be most closely related to the cognitive domain: Science Mark, STEP, TOSA-CCS and the TOUS tests. Tests which became significant when I. Q. was used as covariate appear to be more related to the affective domain: TOSA-ICS and HIFAMS Factor Five.

It seems students who desire a high inquiry-oriented science learning situation perform somewhat better in both cognitive and affective domains than students who desire a low inquiry-oriented science learning situation. The difference in I. Q. scores between the two groups accounts for most of the differences between them in the cognitive domain but not in the affective domain where removal of I. Q. as a covariate adds to the tests which measure significant differences between the groups. These results of these tests help interpret which instruments are measuring in which domain and support earlier reported correlations.

The results obtained from SATS, for reasons discussed earlier, as well as lack of homogeneity of variance are not being interpreted.

Hypothesis 3a is rejected for six of the seven total test scores: HIFAMS, SATS, Science Mark, STEP, TOUS-Ew and TOUS-Jw. It is also rejected for five of the eight subtest scores: HIFAMS Factors 2, 3, 4 and 6 and TOSA-CCS.

Hypothesis 3b is rejected for two of the seven total test scores: HIFAMS and SATS. It is also rejected for six of the eight subtest scores: HIFAMS Factors 2, 3, 4, 5 and 6 and TOSA-ICS.

<u>Hypothesis 4</u> (H_4):

When students are classified as being either matched or not

matched to their science learning situation there are no significant differences among the four resultant groups as indicated by their:

a. Desired science learning situation or D-scores,

b. Actual science learning situation or,

c. Discrepancy scores (D-a).

The objective of Hypotheses 4 and 5 is to test the scores resulting from the SLSI-S instrument for groups of students matched or not matched to their environment.

Utilization of the student groups as described in Table 21 and their Discrepancy scores (D-A) enables the reclassification of Group H, (Table 31) students who desire a high inquiry-oriented environment, into those who are receiving this desired situation and those who aren't. Similarly, imposing Discrepancy scores (D-A) on Group L (Table 31), reclassifies this group into students who desire a low inquiry-oriented environment and are receiving it and students who desire a low inquiry-oriented environment and are not getting what they desire. The result of this splitting is outlined in Table 22. Table 36 summarizes the SLSI and I. Q. scores for these four groups.

As expected, the groups matched to their environments (1 & 3) have the low discrepancy scores (D-A) and the groups not matched to their environments (2 & 4), have higher discrepancy scores. Group 4 which consists of students who desire high inquiry-oriented environment (high D-score) are in a low inquiry-oriented situation (low A-score) as indicated in Table 1. However, Group 2 who desire a low inquiry-oriented situation (low D-score) don't perceive their environment as high inquiry-

TABLE 36

SLSI-SUBTEST AND I.Q. SCORES OF STUDENTS RANKED BY DEGREE OF BEING MATCHED TO SCIENCE LEARNING SITUATION

GROUP	DESCRIPTION	N	D-SCORE		A-SCORE		D - A			MEAN I.Q.
			MEAN	VARIANCE	MEAN	VARIANCE	MEAN	VARIANCE	RANGE	
1	Want Low Inquiry Are Getting	54	2.93	0.09	3.11	0.09	-0.19	0.06	-1.20 to 0.05	103.6
2	Want Low Inquiry Are Not Getting	52	3.19	0.03	2.40	0.08	0.79	0.05	0.49 to 1.66	104.3
3	Want High Inquiry Are Getting	54	3.93	0.03	3.57	0.07	0.36	0.04	-0.25 to 0.65	110.6
4	Want High Inquiry Are Not Getting	52	4.15	0.06	2.49	0.15	1.66	0.16	1.14 to 2.74	108.1

oriented (high A-score) but as lower than that desired (low A-score).

The Group 2 situation can be interpreted as indicating that the students in this group desire a teacher who exhibits the variety of characteristics described in SLSI-TMC to a low degree, but they do desire a teacher who exhibits them to some degree. These students may have teachers who use only one method of presentation; such a teacher would score very low on the SLSI-TMC or SLSI-A subtests. That this is the case is indicated in Table 36. A relatively wide range in I.Q. scores for the four groups is also indicated; these should be considered in further analyses. That these scores are significantly different at the 0.01 level is shown by analysis of variance and the results are presented in Appendix K.

The Bartlett Test (Table 37) shows there is lack of homogeneity of group variances for all three comparisons ($p < 0.01$). This violates one of the assumptions underlying the analysis of variance (Ferguson, 1966, p. 294). Both Ferguson (1966, p. 295) and Winer (1962, p. 96) indicate analysis of variance may still be used since the homogeneity tests are oversensitive to departures from normality of the distributions and reasonable departures from the assumptions may occur without seriously affecting the validity of inferences drawn from the data. A desirable feature of the data in the present study is the reasonably large and equal cell n's (Winer, 1962, p. 95). Comparing the actual values (Table 36) indicates a reasonable consistency between most pairs of variances. In addition, one might suspect differences in variances in these tests since they are predictor variables and should reflect group differences. Perhaps analysis of variance should not be used to reveal differences

TABLE 37

ANALYSIS OF VARIANCE ON SLSI SUBSCORES FOR THE FOUR TREATMENT GROUPS

BASED ON DEGREE OF BEING MATCHED TO SCIENCE LEARNING SITUATION

SLSI SUBSCORES	SOURCE					BARTLETT-BOX TESTS OF HOMOGENEITY OF GROUP VARIANCES	
	S.S.	D.F.	M.S.	F-RATIO	PROB.	CHISQ	PROB.
A - Score							
Effects	48.13	3.	16.04	166.09	<0.001	11.87	0.007
Errors	20.09	208.	0.09				
D - Score							
Effects	54.11	3.	18.03	330.55	<0.001	22.91	<0.001
Errors	11.35	208.	0.05				
D - A Score							
Effects	96.06	3.	32.02	409.20	<0.001	29.97	<0.001
Errors	16.27	208.	0.07				

between these scores but two further considerations may make its use acceptable: 1) the probability level at which differences are found and 2) homogeneity of variance in the criterion measures.

Results of the analysis of variance of the three scores for the four groups are given in Table 37.

Scheffe Multiple Comparisons (Table 38 and Appendix L) show the only SLSI-S subtest difference between individual groups not significant at the 0.001 level is the A-score between Groups 2 and 4. This indicates Groups 2 and 4 do not perceive their actual science learning situations as significantly different.

Of primary significance are the D-scores; to the degree that these are significantly different for each group and are higher for those groups indicating a desire for a high-inquiry oriented environment the content validity of SLSI-S is strongly supported. These differences were all significant at $p < 0.001$. In addition these scores indicate each group desires a significantly different science learning situation.

The null hypothesis is rejected in all cases except for the A-score between Groups 2 and 4, that is, the four groups have significantly different scores indicating the type of environment they desire and the degree to which they are matched with it. In only one case do two of the groups have similar scores and that is their perception of the actual science learning situation. These two groups are the ones not matched to their desired science learning situation and although Group 2 desires a low inquiry-oriented science learning situation and Group 4 desires a high inquiry-oriented science learning situation both groups perceive

TABLE 38

SCHEFFE MULTIPLE COMPARISONS PROBABILITY MATRICES

FOR SLSI-S SUBSCORES

	A-Score					D-Score					D-A Score			
	G1	G2	G3	G4		G1	G2	G3	G4		G1	G2	G3	G4
G1					G1					G1				
G2	<0.001				G2	<0.001				G2	<0.001			
G3	<0.001	<0.001			G3	<0.001	<0.001			G3	<0.001	<0.001		
G4	<0.001	0.50	<0.001		G4	<0.001	<0.001	<0.001		G4	<0.001	<0.001	<0.001	

their actual situation as the same. Further, they perceive their actual situation as very low in inquiry-orientedness. A possible explanation for this was mentioned above; the students may have teachers who use only one method of presentation.

Hypothesis 5 (H_5):

When students are classified as being either matched or not matched to their science learning situation there are no significant differences among the four resultant groups when I. Q. is used as a covariate as indicated by their

a. Desired science learning situation or D-scores,

b. Actual science learning situation or A-scores,

c. Discrepancy scores, (D-A).

Table 39 presents the results of the analysis of covariance. Analysis of covariance left all significant differences as they were before I. Q. was used as covariate. Although the four groups appear to have different average I. Q. scores (Table 36) they have no relationship with the student's perception of their actual and desired science learning situation. This finding supports the content validity of the SLSI-S instrument.

Table 40 presents the results of Scheffe Multiple Comparisons (Analysis of Variance is presented in Appendix K) on the significance of I. Q. in the four treatment groups. I. Q. scores are only significantly different at the 0.05 level between Groups 1 and 3: those matched with their environment.

TABLE 39

ANALYSIS OF COVARIANCE OF SLSI SUBSCORES FOR THE FOUR TREATMENT GROUPS BASED ON DEGREE OF BEING MATCHED TO THE SCIENCE LEARNING SITUATION

SLSI SUBSCORES	SOURCE					BARTLETT-BOX TESTS OF HOMOGENEITY OF GROUP VARIANCES	
	S.S.	D.F.	M.S.	F-RATIO	PROB.	CHISQ	PROB.
1st Dependent Variable							
A-Score							
Effects	44.59	3.	14.86	149.08	<0.001	9.17	0.003
Cov 1	0.00	1.	0.00	0.03	0.84		
Errors	19.34	194.	0.09				
2nd Dependent Variable							
D-Score							
Effects	46.93	3.	15.64	289.08	<0.001	22.94	<0.001
Cov 1	0.18	1.	0.18	3.36	0.068		
Errors	10.49	194.	0.05				
3rd Dependent Variable							
D-A Score							
Effects	84.42	3.	28.14	357.12	<0.001	21.32	<0.001
Cov 1	0.13	1.	0.13	1.69	0.20		
Errors	15.28	194.	0.07				

TABLE 40

SCHEFFE MULTIPLE COMPARISON MATRIX OF PROBABILITIES OF SIGNIFICANCE OF I. Q. IN THE FOUR TREATMENT GROUPS BASED ON DEGREE OF BEING MATCHED TO THE SCIENCE LEARNING SITUATION

	G1	G2	G3	G4
G1				
G2	0.98			
G3	0.03	0.08		
G4	0.22	0.40	0.87	

Hypothesis 5 is rejected; I. Q. has no effect on the D, A and D-A scores.

<u>Hypothesis 6</u> (H_6):

When students are classified as being either matched or not matched to their science learning situation there are no significant differences among the four resultant groups in their performance on the following criterion measures: HIFAMS, I. Q., SATS, Science Mark, STEP, TOSA, TOUS-Ew and TOUS-Jw.

Table 41 presents the means and variances of the four treatment groups on each criterion measure. Table 42 presents the results of analysis of variance for the four treatment groups on each of the criterion measures. All criterion measures indicated homogeneity of variance as given by the Bartlett-Box test on the computer print-out ($p > 0.05$) with the exception of SATS where $p = 0.04$. Nine of the fifteen criterion measures show significant differences: eight at the 0.01 level and one at the 0.05 level.

Hypothesis 6 is rejected for nine of the fifteen criterion measures. In addition, looking at the performance of the individual groups (Table 43) provides data for more detailed interpretation. Table 44 summarizes the findings from Tables 42 and 43. Where significant differences are found Group 3 most frequently had the highest score and Group 2 most frequently had the lowest score on the criterion measures. SATS, consistent with earlier discussion, again measured oppositely to the other instruments. In the Scheffe Comparisons, Groups 3 and 2, those matched with a high inquiry-oriented environment and those

TABLE 41

MEANS AND VARIANCES OF THE FOUR TREATMENT GROUPS BASED ON DEGREE OF BEING MATCHED TO THE SCIENCE LEARNING SITUATION ON SEX AND CRITERION MEASURES

CRITERION MEASURE	GROUP							
	Group 1 (N=54)		Group 2 (N=52)		Group 3 (N=54)		Group 4 (N=52)	
	$\bar{X}$	S^2	$\bar{X}$	S^2	$\bar{X}$	S^2	$\bar{X}$	S^2
	1.46	0.25	1.56	0.25	1.46	0.25	1.64	0.24
HIFAMS TOTAL	132.6	165.5	124.6	222.2	138.8	126.4	129.9	192.3
F1:[a] SCHOOL OFFERS	27.2	14.3	25.2	17.5	27.9	15.7	25.2	15.6
F2: TEACHER IMPORTANCE	27.4	16.9	26.4	24.8	29.9	13.0	27.9	13.6
F3: PROGRAM IMPORTANCE	30.3	15.1	29.0	15.8	31.4	12.2	31.0	15.7
F4: TEACHER CHARACTERISTICS	15.9	8.1	14.7	8.8	17.2	6.5	15.8	8.8
T5: TMC	11.3	4.4	8.6	5.4	12.1	5.6	9.4	8.2
F6: SOCIAL LIFE	13.3	5.0	13.0	6.8	14.0	4.1	13.7	3.9
SATS	201.1	403.8	221.7	447.6	188.4	485.8	209.6	825.3
SCIENCE MARK	58.6	167.0	56.8	100.4	66.4	194.5	65.2	202.9

TABLE 41 (Cont'd)

Means and Variances .... Sex and Criterion Measures

	GROUP							
	Group 1 (N=54)		Group 2 (N=52)		Group 3 (N=54)		Group 4 (N=52)	
	$\bar{X}$	S^2	$\bar{X}$	S^2	$\bar{X}$	S^2	$\bar{X}$	S^2
STEP	36.8	118.0	37.9	53.2	43.5	78.3	40.1	60.1
TOSA	15.0	20.2	15.3	15.3	16.3	20.6	16.8	15.1
TOSA-CCS	6.7	6.2	6.8	5.8	7.9	6.0	8.0	5.2
TOSA-ICCS	8.3	6.8	8.5	4.3	8.4	9.0	8.8	6.8
TOUS-Ew	20.4	27.6	21.0	20.4	24.2	12.3	23.2	24.4
TOUS-Jw	23.4	53.4	23.8	42.9	27.5	17.2	24.9	46.6

[a]Factors described in Chapter III.

TABLE 42

ANALYSIS OF VARIANCE ON CRITERION MEASURES FOR THE FOUR TREATMENT GROUPS BASED ON DEGREE OF BEING MATCHED TO THE SCIENCE LEARNING SITUATION

CRITERION MEASURE	SOURCE					BARTLETT-BOX TESTS OF HOMOGENEITY OF GROUP VARIANCES	
	S.S.	D.F.	M.S.	F-RATIO	PROB.	CHISQ	PROB.
HIFAMS TOTAL							
Effects	5412.11	3.	1804.03	10.28	<0.001	4.26	0.23
Errors	35798.00	204.	175.48				
F1: SCHOOL OFFERS							
Effects	314.03	3.	104.67	6.64	<0.001	0.53	0.91
Errors	3215.12	204.	15.76				
F2: TEACHER IMPORTANCE							
Effects	346.18	3.	115.39	6.79	<0.001	6.83	0.08
Errors	3462.18	204.	16.97				
F3: PROGRAM IMPORTANCE							
Effects	170.58	3.	56.86	3.88	<0.001	1.13	0.77
Errors	2988.87	204.	14.65				

TABLE 42 (Cont'd)

Analysis of Variance .... Science Learning Situation

CRITERION MEASURE	SOURCE					BARTLETT-BOX TESTS OF HOMOGENEITY OF GROUP VARIANCES	
	S.S.	D.F.	M.S.	F-RATIO	PROB.	CHISQ	PROB.
F4: TEACHER CHARACTER-ISTICS							
Effects	164.21	3.	54.73	6.83	<0.001	1.58	0.66
Errors	1634.21	204.	8.01				
F5: TMC							
Effects	394.28	3.	131.42	22.42	<0.001	5.06	0.17
Errors	1195.80	204.	5.86				
F6: SOCIAL LIFE							
Effects	31.88	3.	10.62	2.10	0.10	4.97	0.17
Errors	1008.05	204.	4.94				
SATS							
Effects	30684.73	3.	10228.24	19.05	<0.001	8.16	0.04
Errors	110010.00	205.	536.63				
SCIENCE MARK							
Effects	3559.21	3.	1186.40	7.14	<0.001	7.19	0.07
Errors	34054.69	205.	116.12				

TABLE 42. (Cont'd)

Analysis of Variance .... Science Learning Situation

CRITERION MEASURE	SOURCE					BARTLETT-BOX TESTS OF HOMOGENEITY OF GROUP VARIANCES	
	S.S.	D.F.	M.S.	F-RATIO	PROB.	CHISQ	PROB.
STEP							
Effects	561.48	3.	187.16	2.36	0.08	6.21	0.10
Errors	6570.31	83.	79.16				
TOSA							
Effects	44.22	3.	14.74	0.81	0.49	2.87	0.41
Errors	1507.54	83.	18.16				
TOSA-CCS							
Effects	30.43	3.	10.14	1.70	0.17	2.15	0.54
Errors	494.76	83.	5.96				
TOSA-ICS							
Effects	2.40	3.	0.80	0.11	0.95	4.71	0.19
Errors	561.83	83.	6.76				

TABLE 42 (Cont'd)

Analysis of Variance .... Science Learning Situation

CRITERION MEASURE	SOURCE					BARTLETT-BOX TESTS OF HOMOGENEITY OF GROUP VARIANCES	
	S.S.	D.F.	M.S.	F-RATIO	PROB.	CHISQ	PROB.
TOUS-Ew							
Effects	214.58	3.	71.52	3.25	0.03	5.37	0.15
Errors	1821.55	83.	21.94				
TOUS-Jw							
Effects	219.54	3.	73.18	1.75	0.16	8.37	0.04
Errors	3467.66	83.	41.77				

TABLE 43

SCHEFFE MULTIPLE COMPARISON PROBABILITIES FOR THE FOUR TREATMENT GROUPS[a] ON THE CRITERION MEASURES

CRITERION MEASURES	COMPARISON					
	G2 - G1	G3 - G1	G3 - G2	G4 - G1	G4 - G2	G4 - G3
HIFAMS TOTAL	0.03	0.12	<0.001	0.78	0.26	<0.01
F1:[a] SCHOOL OFFERS	0.08	0.82	<0.01	0.07	1.00	<0.01
F2: TEACHER IMPORTANCE	0.70	0.02	<0.001	0.95	0.39	0.08
F3: PROGRAM IMPORTANCE	0.43	0.45	0.02	0.83	0.09	0.93
F4: TEACHER CHARACTERISTICS	0.23	0.10	<0.001	1.00	0.30	0.09
F5: TMC	0.00	0.44	<0.001	<0.01	0.45	<0.001
F6: SOCIAL LIFE	0.88	0.46	0.13	0.85	0.42	0.93
SATS	0.09	<0.001	<0.001	1.00	0.07	<0.001
SCIENCE MARK	0.92	0.02	<0.01	0.08	0.02	0.97
STEP	0.93	0.00	0.01	0.26	0.60	0.29

TABLE 43 (Cont'd)

Scheffe Multiple .... Criterion Measures

CRITERION MEASURES	COMPARISON					
	G2 - G1	G3 - G1	G3 - G2	G4 - G1	G4 - G2	G4 - G3
TOSA	0.99	0.54	0.71	0.20	0.33	0.94
TOSA-CCS	0.99	0.11	0.19	0.05	0.09	0.99
TOSA-ICS	1.00	1.00	1.00	0.86	0.94	0.91
TOUS-Ew	0.93	<0.001	<0.01	0.02	0.08	0.77
TOUS-Jw	0.99	0.01	0.03	0.67	0.85	0.23

[a]Group Characteristics (See Table 22)
- G1 matched; low D-Score
- G2 not matched; low D-Score
- G3 matched; high D-Score
- G4 not matched; high D-score

TABLE 44

A SUMMARY OF COMPARISON OF MEANS OF CRITERION MEASURES FOR THE FOUR TREATMENT GROUPS

CRITERION MEASURE	Rank of Groups (highest first)	p-Value from ANOVA	p-Value for Group Comparisons					
			G2-G1	G3-G1	G3-G2	G4-G1	G4-G2	G4-G3
HIFAMS TOTAL	3-1-4-2	<0.001	0.03		0.00			0.01
F1:[a] SCHOOL OFFERS	3-1-2-4	<0.001	0.08		0.00	0.07		0.01
F2: TEACHER IMPORTANCE	3-4-1-2	<0.001		0.02	0.00			0.09
F3: PROGRAM IMPORTANCE	3-4-1-2	<0.01			0.02		0.09	
F4: TEACHER CHARACTERISTICS	3-4-1-2	<0.01			0.00			0.09
F5: TMC	3-1-4-2	<0.01	0.00		0.00	0.00		0.00
F6: SOCIAL LIFE	3-4-1-2	0.10						
SATS	2-1-4-3	<0.001	0.09	0.00	0.00		0.07	0.00
SCIENCE MARK	3-4-1-2	<0.001		0.02	0.00	0.08	0.02	
STEP	3-4-3-1	0.08		0.00	0.01			

TABLE 44 (Cont'd)

A Summary .... Treatment Groups

Criterion Measure	Rank of Groups (highest first)	p-Value from ANOVA	p-Value for Group Comparisons					
			G2-G1	G3-G1	G3-G2	G4-G1	G4-G2	G4-G3
TOSA	4-2-3-1	0.49						
TOSA-CCS	4-3-2-1	0.17				0.05	0.09	
TOSA-ICS	4-3-2-1	0.95						
TOUS-Ew	3-4-2-1	0.03		0.00	0.01	0.02	0.08	
TOUS-Jw	3-4-2-1	0.16		0.01	0.03			

[a] Factors are defined in Chapter III.

not matched with a desired low inquiry-oriented environment, show significant differences on eleven of the fifteen measures; only TOSA and its two subtests plus HIFAMS Factor 6 show no significant differences between the two groups. Groups 1 and 4, those matched with a low inquiry-oriented environment and those not matched with a desired high inquiry-oriented environment, are most frequently alternating as the second and third ranked groups. When there are significant differences between Groups 1 and 4 it appears as if Group 4 most frequently does well on instruments with a strong cognitive component and Group 1 most frequently does better when there is an affective component.

It appears that students who are matched with their desired environments (Groups 3 and 1) express positive attitudes about their environment but students who are high inquiry-oriented, as compared with students who are low inquiry-oriented, do better on cognitive instruments whether or not they are matched with their environment.

Hypothesis 7 (H_7):

When students are classified as being either matched or not matched to their science learning situation there are no significant differences among the four resultant groups in their performance on the following criterion measures: HIFAMS, I. Q., SATS, Science Mark, STEP, TOSA, TOUS-Ew and TOUS-Jw, when I. Q. is used as a covariate.

The results of the analysis of covariance appear in Appendix M. Only two changes are noted when the four treatment groups are analyzed by analysis of covariance with I. Q. as covariate: HIFAMS Factor 3,

Program Importance, remains significant but only at the 0.02 level and TOUS-Ew shows no significant differences among the groups.

Hypothesis 7 is rejected for eight of the fifteen criterion measures. That is, with one exception, the results of testing Hypothesis 7 are the same as for H_6: except for TOUS-Ew, I. Q. does not affect the performance of the four treatment groups on the criterion measures. These performances have already been discussed under Hypothesis 6.

Summary From Testing Hypotheses

The goal of the study was to develop a method of describing science learning situations in terms of teaching mode characteristics and subsequently use these descriptions to predict student behaviors in cognitive and affective areas.

Some answers to the questions posed earlier under the statement of the problem are worthy of consideration. The pilot study indicated student's perceptions of their science learning situations were of value in predicting their classroom achievements. Subsequently, in the main study it was shown that all three reference groups, the student, the teacher and the teacher's associate produced scores which could be used to categorize teachers as high or low inquiry-oriented but that none of the classifications was particularly successful in predicting student behaviors. Both the student's and the teacher's ranking methods identified those teachers whose students performed better on HIFAMS, indicating the students attitudes towards school. In both cases the students of the teachers rated as most inquiry-oriented performed better indicating

a positive relationship between students of teachers classified as inquiry-oriented by themselves or their students and the students' attitudes towards their school. The teacher's associates' rankings of the teacher produced no predictive information.

However, when the student and not the classroom was considered as the unit of classification, those students classified as desiring a high inquiry-oriented science learning situation did significantly better than students desiring a low inquiry-oriented science learning situation on ten of the fifteen affective and cognitive measures. Specifically, they performed better on HIFAMS and four of its subtests, Science Mark, STEP, TOSA-CCS, TOUS-Ew and TOUS-Jw. I. Q. had a slight effect on the results with the students desiring high inquiry-oriented having significantly higher I. Q.'s than those desiring low inquiry-oriented situations. Using I. Q. as a covariate eliminates most of the significant differences between the two groups on the cognitive measures (Science Mark, STEP, TOSA-CCS, TOUS-Ew and TOUS-Jw) but increases the significant differences on affective measures. Affective measures showing significant differences between the groups include HIFAMS, HIFAMS Factors 2, 3, 4, 5 and 6, and TOSA-ICS.

After the students were classified as desiring a high or low inquiry-oriented science learning situation by being ranked on the basis of their D-scores they were reassociated with their teachers. All classes tested were split fairly evenly with respect to students desiring high inquiry-orientedness and students desiring low inquiry-orientedness. That is, the classes appeared to be reasonably heterogeneous with respect to this characteristic.

When students were subsequently divided into four groups indicating being matched or not matched to their desired degree of inquiry-orientedness several significant differences in the groups were identified. Students who desire and are matched to a high inquiry-oriented situation tend to perform best in all affective and cognitive areas. Students who desire high inquiry-oriented science learning situations but are not experiencing them tend to perform better than students who desire low inquiry-oriented situations and are experiencing them in cognitive areas but the reverse is true in affective areas. Students who desire low inquiry-oriented science learning situations and are not getting them tend to perform poorest in all measured areas.

It appears that students who are matched with the science learning situation they desire perform well on instruments measuring affective attributes: they perceive an attempt is being made to meet their needs. Students who desire a high inquiry-oriented science learning situation have the ability to do well on cognitive instruments in spite of the system but do better if they are matched with the learning situation they desire. Students who desire a low inquiry-oriented science learning situation appear to require the most help from the system and if they don't receive it perform poorly in all areas.

Table 32 showed that the classrooms were reasonably evenly split with respect to students who indicated a desire for high inquiry-orientedness and students who indicated a desire for low inquiry-orientedness. Table 45 indicates this split no longer remains when students are classified into the four groups which are matched or not matched with their environments. The students of each teacher appear to cluster together

TABLE 45

NUMBER OF STUDENTS FROM EACH OF SIX TEACHERS IN EACH OF THE FOUR TREATMENT GROUPS

TEACHER	1	2	3	4
A	3	4	2	13
B	2	14	1	15
C	4	4	2	6
D	12	7	13	2
E	32	16	35	12
F	1	8	1	6
TOTAL	54	53	54	54

in Groups 1 and 3 or 2 and 4. That is, they group together into those who perceive their environment as the one they desire, whether it be low or high inquiry-oriented and those who perceive their environment as undesirable. This trend is emphasized by the portrayal of these data on classroom type in Table 46. Interpreting Table 46, the teachers participating in the present study appear to operate in a science learning situation which can be categorized according to discrepancy scores as either matched or unmatched with that desired by their students. However, it is suggested that this is not a dichotomous classification but, if a larger number of teachers were used, would show as a continuum as illustrated earlier in Figure 3. The data in Table 46 support this idea of a continuum as the percentage of students classified as matched-unmatched varies from 88:12 to 9:91.

It appears that some teachers, to a significant degree, can and do cater to students who desire different learning styles in a given classroom. It also appears that the opposite may be the case.

In addition, as a result of the student's classification of themselves (D-score), their actual science learning situation (A-score) and the discrepancy between the two (D-A), their results on previously identified measures in the affective and cognitive domains can be predicted. These relationships are represented in the model in Figure 2.

TABLE

PERCENTAGE OF STUDENTS FROM EACH TEACHER CLASSIFIED AS BEING IN MATCHED OR UNMATCHED SCIENCE LEARNING SITUATIONS

	SCIENCE LEARNING SITUATION	
TEACHER	UNMATCHED (Groups 2 & 4)	MATCHED (Groups 1 & 3)
A	77	23
B	91	9
C	63	37
D	26	74
E	30	71
F	12	88

CHAPTER V

SUMMARY, CONCLUSIONS AND IMPLICATIONS

The goal of this study was to develop a method of describing science learning situations in terms of teaching mode characteristics and subsequently to use these descriptions in predicting specified student cognitive and affective behaviors. To predict student cognitive and affective behaviors the usefulness of using the student, the teacher or a teacher's associate in rating the learning situation as high or low inquiry-oriented was investigated. Next a student's desire for high or low inquiry-oriented science instruction was used to predict resultant affective and cognitive behaviors and finally the degree of match of a student's desire for inquiry-orientedness and his actual science learning situation was used as a predictor for the individual's cognitive and affective behaviors. Results of the analyses yield implications for methodologies of identifying teaching mode characteristics, relationships between desired learning situations and cognitive and affective attributes of students and results of matching students with their desired science learning situation.

A model was presented to relate these interactions (Figure 2). The findings of the study in relation to this model are now presented. Subsequently the findings are discussed as they relate to the review of the literature. Finally implications and recommendations are given.

Results In Terms Of The Model For The Study

The model on which the study was based (Figure 2) served to structure the hypotheses, the design and now to integrate the findings.

Results in Terms of Hypotheses Tests

The results of the tests of the hypotheses yield some answers to the questions posed in the section, "Significance of the Study". Furthermore, these results augment and amplify key elements in the model representative of the study (Figure 2).

1. Can the degree of inquiry-orientedness of a classroom be identified and related to any criterion measures?

Hypothesis 1 indicated the degree of inquiry-orientedness of a classroom could be identified by each of the three methods: teacher, teacher's associate and student. However, as indicated by the results of Hypothesis 2, when the classroom is used as the unit of comparison only results in the affective domain as indicated by student's attitudes towards his school and predicted by students or teachers are significant. In each case classrooms classified as high inquiry-oriented had more positive results than classrooms classified as low inquiry-oriented.

2. Do different groups, e.g. teachers, students and external evaluators view a given teaching-learning situation equivalently?

Hypothesis 1 would indicate these different groups do not view a given classroom equivalently. This idea is supported by the results of Hypothesis 2 in which high inquiry-oriented classes identified by each of the rating groups (teachers, students, teacher's associates) were compared with their low inquiry-oriented counterparts on each of the

criterion measures. Different results were obtained from each method of classification. The predictive ability of the perception of each group is also indicated in that the classification as produced by the teacher's associate produced no significant differences on the criterion measures, but the student's and the teacher's classifications showed that the two resulting groups were significantly different with respect to their attitude towards their school. In each case the students in the classes identified as having high inquiry-oriented teachers had more positive attitudes than their low inquiry-oriented counterparts. When the students were used for classification of their teachers an additional significant difference between the two resulting groups occurred: students of teachers classified as higher in inquiry-orientedness had significantly higher I. Q. scores.

For predictive purposes the different rating sources do not view the teachers similarly; none of the rating groups produced a large number of significant differences, particularly in the cognitive domain, as indicated by the criterion measures.

3. Do different students desire different learning environments, and, if they do, what is the effect of this desire on their achievements?

The results of Hypothesis 3 indicate that students can be separated into groups who either have a desire for high inquiry-oriented instruction or a desire for low inquiry-oriented instruction and that the students who desire high inquiry-oriented instruction do significantly better on most measures of affective and cognitive behaviors. Further, if I. Q. is used as covariate differences between these groups tend to

disappear in the cognitive domain but differences in the affective domain are increased.

When the students in the present study were compared with respect to which teachers they had they were found to be about evenly split, that is, each classroom was relatively heterogeneous with respect to students desiring a low inquiry-oriented science learning situation and students desiring a high inquiry-oriented science learning situation.

4. What is the effect of students being matched or not matched to their desired science learning situation?

Hypothesis 4, 5, 6 and 7 deal with this question and the feasibility of classifying students as belonging to identifiable groups.

Scores describing the science learning situation were obtained for the treatment group allowing their classification into one of four situations: matched or not matched with a high inquiry-oriented situation; matched or not matched with a low inquiry-oriented situation. The results of these groupings proved to be significant: students matched with a high inquiry-oriented situation generally performed best on all criterion measures, students desiring a high inquiry-oriented situation but not receiving it did well on cognitive measures, students matched with a low inquiry-oriented situation did well on affective measures and students desiring a low inquiry-oriented situation, but not receiving it, generally achieved lowest scores on all measures.

5. Is inquiry-oriented instruction a key pedagogical tool in science education?

This study utilized characteristics of inquiry-oriented instruction to classify teaching-learning situations and suggests several possible answers to the posed problems. Of importance in considering this

question is the apparent ability of some teachers to deal with individual students at their desired level of inquiry-orientedness in a heterogeneous situation and conversely, the inability of others to do so.

Of significance when considering the above question are the ratings given to teachers by students desiring a low inquiry-oriented science learning situation but not getting it. These students indicated their teachers were actually providing lower inquiry-orientedness than they desired. Two implications are suggested by this finding: 1) In general, most students desire their teachers to exhibit the variety of instructional characteristics portrayed in the "Science Learning Situation Inventory" but to different degrees, and 2) Some teachers tend to use only one mode of instruction such as dictating notes and thus score very low on a science learning situation inventory of teaching strategies and do not provide adequately for any group of students. There is probably a desirable range in which teachers should operate as indicated by the scores of the students on their preference for an inquiry-oriented science learning situation; this range appears to be approximately 2.9 to 4.2 on a five point scale where 5 indicates high inquiry-orientedness (Table 36). This situation is depicted in Figure 3.

In addition, as earlier stated, some teachers appear to have the flexibility to cater simultaneously to student desires whether they be for a high inquiry-oriented science learning situation or a low inquiry-oriented science learning situation; others appear not to have this ability. However, it is most probable (as indicated in Table 41) that this is not a dichotomous situation but on a continuum; some teachers have more skills than others to identify and react appropriately to

individual student differences. Teachers can probably be viewed as being on a scale of continuous variation of abilities to deal with individual student differences as indicated in Figure 4.

Per cent of students with which teacher is matched.	0	25	50	75	100
Per cent of students with which teacher is not matched.	100	75	50	25	0

Figure 4

Teaching Mode Characteristics Matching Continuum

Where on this scale a given teacher should be placed can be identified with instruments from this study. With this information suggestions could be made as to the desirability of changes in the teaching mode and analysis of students responses on the instrument might indicate the nature of the changes desired.

<u>Summary of Test Results</u>

<u>Predictor Instrument</u>. The SLSI-S instrument appears to adequately deal with the Teaching Mode Characteristics, Actual and Desired, component of the model (Figure 2). When the students were separated into four groups indicating whether they were or were not matched with the degree of inquiry-orientedness they desired the Desire (D), Actual (A), and Discrepancy (D-A) scores of each group were statistically shown to be significantly different. Students who were matched to their environments, Groups 1 and 3, had low Desire (D) scores and high

Desire (D) scores respectively and perceived their teachers as having low discrepancies with their desired science learning situation. Concurrently Groups 1 and 4, who were not matched with their desires science learning situations had statistically high discrepancy scores. These findings indicate content validity of the instrument and the feasibility of using the scores for separating groups for subsequent analysis.

Students who were not satisfied with their science learning situation and had the same teacher tended to give the teacher the same Actual (A) score despite having very different Desire (D) scores themselves. This is also taken as an indication of the content validity of the Science Learning Situation Inventory. That is, one group of students indicated a desire for a high inquiry-oriented science learning situation and another group indicated a desire for a low inquiry-oriented science learning situation. Both groups of students had the same teacher and agreed on their perceptions of their actual science learning situation.

Criterion Measures. Low correlations among the criterion measures indicate they are likely measuring attributes from different domains. From the nature of the tests and these correlations it is suggested the variety of student characteristics sampled represent both the affective and cognitive domains. This indicates achievement of an objective of the study: to identify and use instruments which measure student behaviors in both the affective and cognitive domains. The model representative of the study (Figure 2) includes these two domains

and results of the various hypothesis tests indicate which instruments probably measure behaviors in each domain. Instruments measuring student behaviors in the cognitive domain appear to include STEP, Science Mark, TOUS-Ew, TOUS-Jw, TOSA-TOTAL, TOSA-CCS. Student behaviors in the affective domain appear to be measured by TOSA-ICS, HIFAMS and its six factors.

Summary. The model presented in Figure 2 appears to provide a conceptual framework for integrating the findings of the present study. These findings include the relevance of Teaching Mode Characteristics for describing science learning situations and their subsequent use as predictor variables for student behaviors. These student behaviors are shown to be identifiable in different domains: affective and cognitive. The effects of what a student desires in his science learning situation as well as the interaction between what he desires as compared with what he actually gets on his cognitive and affective behaviors are shown to be significant: these relationships are summarized in the model.

Discussion Of The Findings From The Present Study In Relation To The Review Of The Literature

The findings presented above are herein related to the topics from the review of the literature.

Inquiry-oriented Instruction. The characteristics of inquiry-oriented instruction as gleaned from the literature and as reflected in the SLSI-S instrument resulted in a useful portrayal of important teaching-learning activities which go on in the classroom. An earlier

criticism of research on inquiry-oriented instruction was with the unnatural settings produced in establishing treatment groups. In the present study the teacher's natural style of instruction is used to rank him on a contimuum of inquiry-orientedness. This methodology proved to be successful in establishing predictor scores which could be related to student cognitive and affective behaviors.

The utilization of natural classroom situations to define the degree of inquiry-oriented instruction is also important in that the use of the resultant instrument (SLSI-S) by other teachers is made practical. Norms for grade nine classrooms in Alberta are available from the present study.

Is inquiry-oriented instruction desirable? As described above, students generally do desire inquiry-oriented instruction as defined by the instrument SLSI-S, but in varying degrees: approximately 2.9 to 4.5 on a five-point scale with 5 indicating the highest degree of inquiry-orientedness. However, inquiry-oriented instruction per se does not appear to be the crucial variable in determining student behavior but the students desire for inquiry-orientedness and whether or not he is actually in his desired science learning situation appear to be the crucial variables.

Describing the Learning Situation. The learning situation can be described in terms of inquiry-orientedness as defined in this study; the source of the description appears to be an important variable. Elliot (1974) and the pilot study suggested the teacher's peer as a valuable potential source; Elam (1974), Purchit (1970), Thompson (1974), Rayder (1970), Costin and Menges (1971), Walberg (1969a) and the pilot

study support the position that the student's view is the most valid and reliable source of information about the science learning situation.

As reported above, it appears none of the sources is very adequate when the classroom is taken as the unit of study. However, the student's view of his science learning situation as an individual is valuable as a predictor of his affective and cognitive attributes.

Relationships between Teaching Mode Characteristics and Student Attributes. Emmer (1974), Harrison and Westerman (1973), and Walberg (1969a) investigated relevant aspects of the student's view of his teaching-learning environment and supported the utilization of his view over other possible sources as predictively valid. The present study has augmented and built on their work by 1) defining and identifying characteristics of teaching modes, 2) identifying instructional activities teachers can emphasize for different objectives (SLSI-S) and 3) showing how these activities or characteristics relate to different student behaviors.

The present study supports these reviewed studies in that, as presented above, the student's individual view of his science learning situation proved to be the most important in relating the Teaching Mode Characteristics to student affective and cognitive behaviors.

Matching Students and Learning Situations. In addition to the questions and findings on the utilization of students to describe classroom learning situations (Emmer, 1974; Harrison and Westerman, 1973; Walberg, 1969a, 1970), Hunt (1974) suggests matching students to their learning environment. The present study, as reported above, adds

information to the matching question in two ways: 1) by showing that students who prefer a high inquiry-oriented science learning situation most frequently perform better than students who prefer a low inquiry-oriented situation in both the affective and cognitive domains when I.Q. is not considered and in just the affective domain when I.Q. is used as covariate, and 2) when each group is matched or not matched to their desired environment the four resultant groups perform differently, with the high-matched group usually performing best on all affective and cognitive instruments, the high-unmatched group performing second best on cognitive-oriented instruments, the low-matched group performing second best on attitude-oriented instruments, and the low-unmatched group usually performing poorest on all instruments. These findings parallel Hunt's (1974, p. 222) basic matching principle, "Low CL [conceptual level] learners profit more from high structure and high CL learners profit more from low structure or, in some cases, are less affected than low CL learners by variations in structure". The present study adds a major dimension to this finding by considering the affective domain. In this case the students matched with a low inquiry-oriented situation performed better than those students desiring, but not getting, a high inquiry-oriented situation.

Hunt's definitions of high conceptual level and low structure are assumed to be similar to the definitions used in the present study for high inquiry-orientedness.

<u>The Matching Model and Inquiry-Oriented Instruction</u>. When classrooms were checked to ascertain whether the students contained therein

predominantly preferred either high inquiry- or low inquiry-oriented instruction they were found to be predominantly heterogeneous (Table 32). However, when students were checked to see which teachers they had after being classified as matched or unmatched with either high or low inquiry-oriented environments, the students who claimed to be matched usually had one set of teachers and students who claimed to be unmatched had another set of teachers (Table 46). It appears some teachers adapt to a student's desired learning situation no matter what it is and others do not. The idea that teacher ability to adapt to student desires may be on a continuum was previously discussed and illustrated (Figure 4).

This finding of ability of teachers to adapt to a variety of student's desires constitutes a significant difference with respect to implications when compared with Hunt's matching model (1974, pp. 208-222). In Hunt's theory separate environments should be established to match the conceptual level of each student; in the present study teachers should be identified who can provide each student in a heterogeneous classroom with the learning situation he desires. In addition, a heterogeneous classroom may be desirable so a student will be exposed to a wider variety of inquiry-orientedness. The idea that heterogeneous classrooms are potentially desirable is based on three points: 1) present study findings that indicate students who desire a high inquiry-oriented science learning situation tend to perform better on both cognitive and affective measures 2) lack of evidence that students remain at a given level with respect to desire for inquiry-orientedness, and 3) the possibility of a student operating at a higher level of inquiry-orientedness is more likely

to occur in a heterogeneous classroom where various levels are in operation than in a homogeneous setting where a student is not only matched to, but locked into, the degree of inquiry-orientedness he desires at a particular time.

Affective and Cognitive Domains. The series of tests used to measure student attributes, appear, as a result of their correlations, to be measuring somewhat distinct characteristics. From the content of the tests it appears both affective and cognitive behaviors are represented as identified above. Science course objectives usually indicate instruction should be provided in both affective and cognitive domains; the present study identified instruments which may be useful in measuring these objectives.

The "Test on Scientific Attitudes" (Kozlow and Nay, 1976), one of the more thoroughly researched instruments, had one of the lowest discrimination abilities. One of the reasons could be that the curriculum in operation lacks inclusion of topics measured by this test. An objective of the present study was to identify instruments which would allow evaluation of student behaviors in areas other than that traditionally indicated by the "science mark". This test plus the others used in this study should be examined by teachers in relation to the objectives for their science courses and the science learning situations they provide.

Implications For Science Educators

The following points are recommended for consideration by science educators at all levels:

1. Areas other than the cognitive domain should be considered with respect to implications for instruction and evaluation. The present study identifies instruments which should be of use in expanding domains of evaluation and associated instructional methods. In addition, Alberta provincial norms at the grade nine level are provided for each test.

Not only do educators require a wide variety of instruments to measure student behaviors but provincial norms should be available on these instruments to aid in the consistency of student measurement throughout the province. That is, the teacher can not only check the achievement of his students but can compare his class results with norms indicative of the population. Feedback from this comparison can help the teacher identify areas in which the class may be particularly weak or strong. Such norms are of particular value to the many rural areas where class comparison with a larger population is difficult.

2. Educators should be aware of the different learning situations desired by individual students and attempt to accommodate them by having a wide variety of teaching strategies. An important prerequisite for this consideration is that the teacher know the individual student well. Considerable teacher interaction with small numbers of students could be one method of facilitating teacher knowledge of student science learning situation needs. As well, feedback from students can be obtained by use of instruments such as the "Science Learning Situation Inventory" which indicates the individual's desired science

learning situation and provides the teacher with information about his actual teaching mode characteristics.

Prerequisite to the above is the training of the teacher. Teachers should be trained to identify degrees of inquiry-orientedness desired by individual students. Individuals being prepared as science educators should be aware of the findings of the present study. As such, these individuals should have knowledge of, and practice with, the variety of teacher characteristics identified in the Science Learning Situation Inventory. Central to these instructional strategies is knowledge of and use of the process skills (Nay and Associates, 1971) (Appendix B). These skills form a particularly fertile area for practicing and implementing a variety of degrees of flexibility within a classroom. For example, one student may desire an experimental design which describes the procedure to be used in a series of numbered steps whereas a second student may wish to produce his own design; a continuum of degrees of student freedom exists between these two extremes. Similar situations exist for use of the other process skills and their use in totality. Implications for the practice of these skills extend to University courses teaching science or about science.

Teacher inservice provided by science consultants, supervisors or university personnel is subject to the same suggestions.

3. Since students who desire a high inquiry-oriented science learning situation perform better than students who desire a low inquiry-oriented situation, can any science learning activities be developed that motivate individuals to operate at a higher level of inquiry-orientedness?

Recommendations For Further Research

Research to provide answers to the following questions seems desirable. A suggestion regarding a possible research design follows each question.

1. Can students increase in their desire for a high inquiry-oriented science learning situation?

A pre- and post-test design could be used to investigate this question. Students could be given the SLSI-S questionnaire at the beginning of a science course and again at the end of it to ascertain any changes in their Desire (D) score. Instructors identified by their previous classes as being very perceptive as to student needs (low discrepancy scores) could be assigned to teach the classes (Figure 4).

2. Can teachers be taught to effectively utilize a variety of degrees of inquiry-orientedness? Is this an objective of present teacher training courses?

These questions could be treated as two separate research projects or combined.

To test the second question teacher training courses could be surveyed.

To test the first question teachers could be identified by use of the Science Learning Situation Inventory and those who receive large discrepancy scores take an in-service session designed to teach required instructional skills. These teachers could subsequently be tested by having their next classes again assign them discrepancy scores.

Agencies providing in-service training should perhaps use this technique to ascertain their efficacy.

3. What function does and should the structure of the curriculum contribute to the degree of inquiry-orientedness of the classroom?

Review of the literature indicated present curriculum contributes little to change a teacher's style of instruction. Therefore, this question is related to the previous one and suggests teacher in-service programs be designed to accompany curriculum implementation. The combination of an in-service program and a new curriculum could be researched as suggested for question two.

4. Are degrees of desire for inquiry-orientedness related to I. Q. or Piagetian stages of development?

The "Science Learning Situation Inventory" could be given to a set of classes along with tests identifying the Piagetian stages. In addition I. Q. tests could be administered. Correlations between pairs of variables should prove interesting.

5. Is the desire for inquiry-orientedness related to age or grade level?

The "Science Learning Situation Inventory" could be checked for grade level appropriateness and administered to the suggested grades. The proportion and degree of inquiry-orientedness desired at various grade levels could be ascertained.

6. Are findings from this study true for other subject areas and grade levels?

A parallel form of the "Science Learning Situation Inventory" could be developed and the design of the present study repeated. Instruments to measure student behaviors in the cognitive and affective domains would as in the present study, have to be identified or developed.

In addition to the above questions and research recommendations other suggestions may have potential. Further development of the instruments used in this study could contribute significantly to measurement in, particularly, the affective domain. SATS and TOUS should be further factor analyzed and normed since they appear to have potential in areas which require testing instruments. Much of the value of these tests may be in their factors.

The model (Figure 2) used in the present study could be used to guide further research with statistical analysis by factorial experiments to indicate interaction and main effects of the various SLSI-S subscores and, I. Q. or sex on the criterion measures. That is, more information may be obtained regarding interaction effects. A posteriori tests such as Scheffe Multiple Comparisons could follow. Studies of this type could take into consideration not only the high and low groups of students with respect to desire for inquiry-orientedness but refine the matching to a multi-grouped basis. For example, a certain score on SLSI-D could be used as a predictor instead of just the relative groupings used in the present study. That such matchings may be feasible is strongly indicated in the present study in that the two groups of students who were not matched with their desired science learning situation gave almost identical scores to their teachers.

BIBLIOGRAPHY

TABLE 43

SCHEFFE MULTIPLE COMPARISON PROBABILITIES FOR THE FOUR TREATMENT GROUPS[a] ON THE CRITERION MEASURES

CRITERION MEASURES	COMPARISON					
	G2 - G1	G3 - G1	G3 - G2	G4 - G1	G4 - G2	G4 - G3
HIFAMS TOTAL	0.03	0.12	<0.001	0.78	0.26	<0.01
F1:[a] SCHOOL OFFERS	0.08	0.82	<0.01	0.07	1.00	<0.01
F2: TEACHER IMPORTANCE	0.70	0.02	<0.001	0.95	0.39	0.08
F3: PROGRAM IMPORTANCE	0.43	0.45	0.02	0.83	0.09	0.93
F4: TEACHER CHARACTERISTICS	0.23	0.10	<0.001	1.00	0.30	0.09
F5: TMC	0.00	0.44	<0.001	<0.01	0.45	<0.001
F6: SOCIAL LIFE	0.88	0.46	0.13	0.85	0.42	0.93
SATS	0.09	<0.001	<0.001	1.00	0.07	<0.001
SCIENCE MARK	0.92	0.02	<0.01	0.08	0.02	0.97
STEP	0.93	0.00	0.01	0.26	0.60	0.29

TABLE 43 (Cont'd)

Scheffe Multiple .... Criterion Measures

CRITERION MEASURES	COMPARISON					
	G2 - G1	G3 - G1	G3 - G2	G4 - G1	G4 - G2	G4 - G3
TOSA	0.99	0.54	0.71	0.20	0.33	0.94
TOSA-CCS	0.99	0.11	0.19	0.05	0.09	0.99
TOSA-ICS	1.00	1.00	1.00	0.86	0.94	0.91
TOUS-Ew	0.93	<0.001	<0.01	0.02	0.08	0.77
TOUS-Jw	0.99	0.01	0.03	0.67	0.85	0.23

[a]Group Characteristics (See Table 22)
G1 matched; low D-Score
G2 not matched; low D-Score
G3 matched; high D-Score
G4 not matched; high D-score

TABLE 44

A SUMMARY OF COMPARISON OF MEANS OF CRITERION MEASURES FOR THE FOUR TREATMENT GROUPS

CRITERION MEASURE	Rank of Groups (highest first)	p-Value from ANOVA	p-Value for Group Comparisons					
			G2-G1	G3-G1	G3-G2	G4-G1	G4-G2	G4-G3
HIFAMS TOTAL	3-1-4-2	<0.001	0.03		0.00			0.01
F1:[a] SCHOOL OFFERS	3-1-2-4	<0.001	0.08		0.00	0.07		0.01
F2: TEACHER IMPORTANCE	3-4-1-2	<0.001		0.02	0.00			0.09
F3: PROGRAM IMPORTANCE	3-4-1-2	<0.01			0.02		0.09	
F4: TEACHER CHARACTERISTICS	3-4-1-2	<0.01			0.00			0.09
F5: TMC	3-1-4-2	<0.01	0.00		0.00	0.00		0.00
F6: SOCIAL LIFE	3-4-1-2	0.10						
SATS	2-1-4-3	<0.001	0.09	0.00	0.00		0.07	0.00
SCIENCE MARK	3-4-1-2	<0.001		0.02	0.00	0.08	0.02	
STEP	3-4-3-1	0.08		0.00	0.01			

TABLE 44 (Cont'd)

A Summary .... Treatment Groups

Criterion Measure	Rank of Groups (highest first)	p-Value from ANOVA	p-Value for Group Comparisons					
			G2-G1	G3-G1	G3-G2	G4-G1	G4-G2	G4-G3
TOSA	4-2-3-1	0.49						
TOSA-CCS	4-3-2-1	0.17				0.05	0.09	
TOSA-ICS	4-3-2-1	0.95						
TOUS-Ew	3-4-2-1	0.03		0.00	0.01	0.02	0.08	
TOUS-Jw	3-4-2-1	0.16		0.01	0.03			

[a] Factors are defined in Chapter III.

not matched with a desired low inquiry-oriented environment, show significant differences on eleven of the fifteen measures; only TOSA and its two subtests plus HIFAMS Factor 6 show no significant differences between the two groups. Groups 1 and 4, those matched with a low inquiry-oriented environment and those not matched with a desired high inquiry-oriented environment, are most frequently alternating as the second and third ranked groups. When there are significant differences between Groups 1 and 4 it appears as if Group 4 most frequently does well on instruments with a strong cognitive component and Group 1 most frequently does better when there is an affective component.

It appears that students who are matched with their desired environments (Groups 3 and 1) express positive attitudes about their environment but students who are high inquiry-oriented, as compared with students who are low inquiry-oriented, do better on cognitive instruments whether or not they are matched with their environment.

Hypothesis 7 (H_7):

When students are classified as being either matched or not matched to their science learning situation there are no significant differences among the four resultant groups in their performance on the following criterion measures: HIFAMS, I. Q., SATS, Science Mark, STEP, TOSA, TOUS-Ew and TOUS-Jw, when I. Q. is used as a covariate.

The results of the analysis of covariance appear in Appendix M. Only two changes are noted when the four treatment groups are analyzed by analysis of covariance with I. Q. as covariate: HIFAMS Factor 3,

Program Importance, remains significant but only at the 0.02 level and TOUS-Ew shows no significant differences among the groups.

Hypothesis 7 is rejected for eight of the fifteen criterion measures. That is, with one exception, the results of testing Hypothesis 7 are the same as for H_6: except for TOUS-Ew, I. Q. does not affect the performance of the four treatment groups on the criterion measures. These performances have already been discussed under Hypothesis 6.

Summary From Testing Hypotheses

The goal of the study was to develop a method of describing science learning situations in terms of teaching mode characteristics and subsequently use these descriptions to predict student behaviors in cognitive and affective areas.

Some answers to the questions posed earlier under the statement of the problem are worthy of consideration. The pilot study indicated student's perceptions of their science learning situations were of value in predicting their classroom achievements. Subsequently, in the main study it was shown that all three reference groups, the student, the teacher and the teacher's associate produced scores which could be used to categorize teachers as high or low inquiry-oriented but that none of the classifications was particularly successful in predicting student behaviors. Both the student's and the teacher's ranking methods identified those teachers whose students performed better on HIFAMS, indicating the students attitudes towards school. In both cases the students of the teachers rated as most inquiry-oriented performed better indicating

a positive relationship between students of teachers classified as inquiry-oriented by themselves or their students and the students' attitudes towards their school. The teacher's associates' rankings of the teacher produced no predictive information.

However, when the student and not the classroom was considered as the unit of classification, those students classified as desiring a high inquiry-oriented science learning situation did significantly better than students desiring a low inquiry-oriented science learning situation on ten of the fifteen affective and cognitive measures. Specifically, they performed better on HIFAMS and four of its subtests, Science Mark, STEP, TOSA-CCS, TOUS-Ew and TOUS-Jw. I. Q. had a slight effect on the results with the students desiring high inquiry-oriented having significantly higher I. Q.'s than those desiring low inquiry-oriented situations. Using I. Q. as a covariate eliminates most of the significant differences between the two groups on the cognitive measures (Science Mark, STEP, TOSA-CCS, TOUS-Ew and TOUS-Jw) but increases the significant differences on affective measures. Affective measures showing significant differences between the groups include HIFAMS, HIFAMS Factors 2, 3, 4, 5 and 6, and TOSA-ICS.

After the students were classified as desiring a high or low inquiry-oriented science learning situation by being ranked on the basis of their D-scores they were reassociated with their teachers. All classes tested were split fairly evenly with respect to students desiring high inquiry-orientedness and students desiring low inquiry-orientedness. That is, the classes appeared to be reasonably heterogeneous with respect to this characteristic.

When students were subsequently divided into four groups indicating being matched or not matched to their desired degree of inquiry-orientedness several significant differences in the groups were identified. Students who desire and are matched to a high inquiry-oriented situation tend to perform best in all affective and cognitive areas. Students who desire high inquiry-oriented science learning situations but are not experiencing them tend to perform better than students who desire low inquiry-oriented situations and are experiencing them in cognitive areas but the reverse is true in affective areas. Students who desire low inquiry-oriented science learning situations and are not getting them tend to perform poorest in all measured areas.

It appears that students who are matched with the science learning situation they desire perform well on instruments measuring affective attributes: they perceive an attempt is being made to meet their needs. Students who desire a high inquiry-oriented science learning situation have the ability to do well on cognitive instruments in spite of the system but do better if they are matched with the learning situation they desire. Students who desire a low inquiry-oriented science learning situation appear to require the most help from the system and if they don't receive it perform poorly in all areas.

Table 32 showed that the classrooms were reasonably evenly split with respect to students who indicated a desire for high inquiry-orientedness and students who indicated a desire for low inquiry-orientedness. Table 45 indicates this split no longer remains when students are classified into the four groups which are matched or not matched with their environments. The students of each teacher appear to cluster together

TABLE 45

NUMBER OF STUDENTS FROM EACH OF SIX TEACHERS IN EACH OF THE FOUR TREATMENT GROUPS

TEACHER	1	2	3	4
A	3	4	2	13
B	2	14	1	15
C	4	4	2	6
D	12	7	13	2
E	32	16	35	12
F	1	8	1	6
TOTAL	54	53	54	54

in Groups 1 and 3 or 2 and 4. That is, they group together into those who perceive their environment as the one they desire, whether it be low or high inquiry-oriented and those who perceive their environment as undesirable. This trend is emphasized by the portrayal of these data on classroom type in Table 46. Interpreting Table 46, the teachers participating in the present study appear to operate in a science learning situation which can be categorized according to discrepancy scores as either matched or unmatched with that desired by their students. However, it is suggested that this is not a dichotomous classification but, if a larger number of teachers were used, would show as a continuum as illustrated earlier in Figure 3. The data in Table 46 support this idea of a continuum as the percentage of students classified as matched-unmatched varies from 88:12 to 9:91.

It appears that some teachers, to a significant degree, can and do cater to students who desire different learning styles in a given classroom. It also appears that the opposite may be the case.

In addition, as a result of the student's classification of themselves (D-score), their actual science learning situation (A-score) and the discrepancy between the two (D-A), their results on previously identified measures in the affective and cognitive domains can be predicted. These relationships are represented in the model in Figure 2.

TABLE

PERCENTAGE OF STUDENTS FROM EACH TEACHER CLASSIFIED AS BEING IN MATCHED OR UNMATCHED SCIENCE LEARNING SITUATIONS

TEACHER	SCIENCE LEARNING SITUATION	
	UNMATCHED (Groups 2 & 4)	MATCHED (Groups 1 & 3)
A	77	23
B	91	9
C	63	37
D	26	74
E	30	71
F	12	88

CHAPTER V

SUMMARY, CONCLUSIONS AND IMPLICATIONS

The goal of this study was to develop a method of describing science learning situations in terms of teaching mode characteristics and subsequently to use these descriptions in predicting specified student cognitive and affective behaviors. To predict student cognitive and affective behaviors the usefulness of using the student, the teacher or a teacher's associate in rating the learning situation as high or low inquiry-oriented was investigated. Next a student's desire for high or low inquiry-oriented science instruction was used to predict resultant affective and cognitive behaviors and finally the degree of match of a student's desire for inquiry-orientedness and his actual science learning situation was used as a predictor for the individual's cognitive and affective behaviors. Results of the analyses yield implications for methodologies of identifying teaching mode characteristics, relationships between desired learning situations and cognitive and affective attributes of students and results of matching students with their desired science learning situation.

A model was presented to relate these interactions (Figure 2). The findings of the study in relation to this model are now presented. Subsequently the findings are discussed as they relate to the review of the literature. Finally implications and recommendations are given.

Results In Terms Of The Model For The Study

The model on which the study was based (Figure 2) served to structure the hypotheses, the design and now to integrate the findings.

Results in Terms of Hypotheses Tests

The results of the tests of the hypotheses yield some answers to the questions posed in the section, "Significance of the Study". Furthermore, these results augment and amplify key elements in the model representative of the study (Figure 2).

1. Can the degree of inquiry-orientedness of a classroom be identified and related to any criterion measures?

Hypothesis 1 indicated the degree of inquiry-orientedness of a classroom could be identified by each of the three methods: teacher, teacher's associate and student. However, as indicated by the results of Hypothesis 2, when the classroom is used as the unit of comparison only results in the affective domain as indicated by student's attitudes towards his school and predicted by students or teachers are significant. In each case classrooms classified as high inquiry-oriented had more positive results than classrooms classified as low inquiry-oriented.

2. Do different groups, e.g. teachers, students and external evaluators view a given teaching-learning situation equivalently?

Hypothesis 1 would indicate these different groups do not view a given classroom equivalently. This idea is supported by the results of Hypothesis 2 in which high inquiry-oriented classes identified by each of the rating groups (teachers, students, teacher's associates) were compared with their low inquiry-oriented counterparts on each of the

criterion measures. Different results were obtained from each method of classification. The predictive ability of the perception of each group is also indicated in that the classification as produced by the teacher's associate produced no significant differences on the criterion measures, but the student's and the teacher's classifications showed that the two resulting groups were significantly different with respect to their attitude towards their school. In each case the students in the classes identified as having high inquiry-oriented teachers had more positive attitudes than their low inquiry-oriented counterparts. When the students were used for classification of their teachers an additional significant difference between the two resulting groups occurred: students of teachers classified as higher in inquiry-orientedness had significantly higher I. Q. scores.

For predictive purposes the different rating sources do not view the teachers similarly; none of the rating groups produced a large number of significant differences, particularly in the cognitive domain, as indicated by the criterion measures.

3. Do different students desire different learning environments, and, if they do, what is the effect of this desire on their achievements?

The results of Hypothesis 3 indicate that students can be separated into groups who either have a desire for high inquiry-oriented instruction or a desire for low inquiry-oriented instruction and that the students who desire high inquiry-oriented instruction do significantly better on most measures of affective and cognitive behaviors. Further, if I. Q. is used as covariate differences between these groups tend to

disappear in the cognitive domain but differences in the affective domain are increased.

When the students in the present study were compared with respect to which teachers they had they were found to be about evenly split, that is, each classroom was relatively heterogeneous with respect to students desiring a low inquiry-oriented science learning situation and students desiring a high inquiry-oriented science learning situation.

4. What is the effect of students being matched or not matched to their desired science learning situation?

Hypothesis 4, 5, 6 and 7 deal with this question and the feasibility of classifying students as belonging to identifiable groups.

Scores describing the science learning situation were obtained for the treatment group allowing their classification into one of four situations: matched or not matched with a high inquiry-oriented situation; matched or not matched with a low inquiry-oriented situation. The results of these groupings proved to be significant: students matched with a high inquiry-oriented situation generally performed best on all criterion measures, students desiring a high inquiry-oriented situation but not receiving it did well on cognitive measures, students matched with a low inquiry-oriented situation did well on affective measures and students desiring a low inquiry-oriented situation, but not receiving it, generally achieved lowest scores on all measures.

5. Is inquiry-oriented instruction a key pedagogical tool in science education?

This study utilized characteristics of inquiry-oriented instruction to classify teaching-learning situations and suggests several possible answers to the posed problems. Of importance in considering this

question is the apparent ability of some teachers to deal with individual students at their desired level of inquiry-orientedness in a heterogeneous situation and conversely, the inability of others to do so.

Of significance when considering the above question are the ratings given to teachers by students desiring a low inquiry-oriented science learning situation but not getting it. These students indicated their teachers were actually providing lower inquiry-orientedness than they desired. Two implications are suggested by this finding: 1) In general, most students desire their teachers to exhibit the variety of instructional characteristics portrayed in the "Science Learning Situation Inventory" but to different degrees, and 2) Some teachers tend to use only one mode of instruction such as dictating notes and thus score very low on a science learning situation inventory of teaching strategies and do not provide adequately for any group of students. There is probably a desirable range in which teachers should operate as indicated by the scores of the students on their preference for an inquiry-oriented science learning situation; this range appears to be approximately 2.9 to 4.2 on a five point scale where 5 indicates high inquiry-orientedness (Table 36). This situation is depicted in Figure 3.

In addition, as earlier stated, some teachers appear to have the flexibility to cater simultaneously to student desires whether they be for a high inquiry-oriented science learning situation or a low inquiry-oriented science learning situation; others appear not to have this ability. However, it is most probable (as indicated in Table 41) that this is not a dichotomous situation but on a continuum; some teachers have more skills than others to identify and react appropriately to

individual student differences. Teachers can probably be viewed as being on a scale of continuous variation of abilities to deal with individual student differences as indicated in Figure 4.

Per cent of students with which teacher is matched.	0	25	50	75	100
Per cent of students with which teacher is not matched.	100	75	50	25	0

Figure 4

Teaching Mode Characteristics Matching Continuum

Where on this scale a given teacher should be placed can be identified with instruments from this study. With this information suggestions could be made as to the desirability of changes in the teaching mode and analysis of students responses on the instrument might indicate the nature of the changes desired.

Summary of Test Results

Predictor Instrument. The SLSI-S instrument appears to adequately deal with the Teaching Mode Characteristics, Actual and Desired, component of the model (Figure 2). When the students were separated into four groups indicating whether they were or were not matched with the degree of inquiry-orientedness they desired the Desire (D), Actual (A), and Discrepancy (D-A) scores of each group were statistically shown to be significantly different. Students who were matched to their environments, Groups 1 and 3, had low Desire (D) scores and high

Desire (D) scores respectively and perceived their teachers as having low discrepancies with their desired science learning situation. Concurrently Groups 1 and 4, who were not matched with their desires science learning situations had statistically high discrepancy scores. These findings indicate content validity of the instrument and the feasibility of using the scores for separating groups for subsequent analysis.

Students who were not satisfied with their science learning situation and had the same teacher tended to give the teacher the same Actual (A) score despite having very different Desire (D) scores themselves. This is also taken as an indication of the content validity of the Science Learning Situation Inventory. That is, one group of students indicated a desire for a high inquiry-oriented science learning situation and another group indicated a desire for a low inquiry-oriented science learning situation. Both groups of students had the same teacher and agreed on their perceptions of their actual science learning situation.

Criterion Measures. Low correlations among the criterion measures indicate they are likely measuring attributes from different domains. From the nature of the tests and these correlations it is suggested the variety of student characteristics sampled represent both the affective and cognitive domains. This indicates achievement of an objective of the study: to identify and use instruments which measure student behaviors in both the affective and cognitive domains. The model representative of the study (Figure 2) includes these two domains

and results of the various hypothesis tests indicate which instruments probably measure behaviors in each domain. Instruments measuring student behaviors in the cognitive domain appear to include STEP, Science Mark, TOUS-Ew, TOUS-Jw, TOSA-TOTAL, TOSA-CCS. Student behaviors in the affective domain appear to be measured by TOSA-ICS, HIFAMS and its six factors.

Summary. The model presented in Figure 2 appears to provide a conceptual framework for integrating the findings of the present study. These findings include the relevance of Teaching Mode Characteristics for describing science learning situations and their subsequent use as predictor variables for student behaviors. These student behaviors are shown to be identifiable in different domains: affective and cognitive. The effects of what a student desires in his science learning situation as well as the interaction between what he desires as compared with what he actually gets on his cognitive and affective behaviors are shown to be significant: these relationships are summarized in the model.

Discussion Of The Findings From The Present Study In Relation To The Review Of The Literature

The findings presented above are herein related to the topics from the review of the literature.

Inquiry-oriented Instruction. The characteristics of inquiry-oriented instruction as gleaned from the literature and as reflected in the SLSI-S instrument resulted in a useful portrayal of important teaching-learning activities which go on in the classroom. An earlier

criticism of research on inquiry-oriented instruction was with the unnatural settings produced in establishing treatment groups. In the present study the teacher's natural style of instruction is used to rank him on a contimuum of inquiry-orientedness. This methodology proved to be successful in establishing predictor scores which could be related to student cognitive and affective behaviors.

The utilization of natural classroom situations to define the degree of inquiry-oriented instruction is also important in that the use of the resultant instrument (SLSI-S) by other teachers is made practical. Norms for grade nine classrooms in Alberta are available from the present study.

Is inquiry-oriented instruction desirable? As described above, students generally do desire inquiry-oriented instruction as defined by the instrument SLSI-S, but in varying degrees: approximately 2.9 to 4.5 on a five-point scale with 5 indicating the highest degree of inquiry-orientedness. However, inquiry-oriented instruction per se does not appear to be the crucial variable in determining student behavior but the students desire for inquiry-orientedness and whether or not he is actually in his desired science learning situation appear to be the crucial variables.

Describing the Learning Situation. The learning situation can be described in terms of inquiry-orientedness as defined in this study; the source of the description appears to be an important variable. Elliot (1974) and the pilot study suggested the teacher's peer as a valuable potential source; Elam (1974), Purchit (1970), Thompson (1974), Rayder (1970), Costin and Menges (1971), Walberg (1969a) and the pilot

study support the position that the student's view is the most valid and reliable source of information about the science learning situation.

As reported above, it appears none of the sources is very adequate when the classroom is taken as the unit of study. However, the student's view of his science learning situation as an individual is valuable as a predictor of his affective and cognitive attributes.

Relationships between Teaching Mode Characteristics and Student Attributes. Emmer (1974), Harrison and Westerman (1973), and Walberg (1969a) investigated relevant aspects of the student's view of his teaching-learning environment and supported the utilization of his view over other possible sources as predictively valid. The present study has augmented and built on their work by 1) defining and identifying characteristics of teaching modes, 2) identifying instructional activities teachers can emphasize for different objectives (SLSI-S) and 3) showing how these activities or characteristics relate to different student behaviors.

The present study supports these reviewed studies in that, as presented above, the student's individual view of his science learning situation proved to be the most important in relating the Teaching Mode Characteristics to student affective and cognitive behaviors.

Matching Students and Learning Situations. In addition to the questions and findings on the utilization of students to describe classroom learning situations (Emmer, 1974; Harrison and Westerman, 1973; Walberg, 1969a, 1970), Hunt (1974) suggests matching students to their learning environment. The present study, as reported above, adds

information to the matching question in two ways: 1) by showing that students who prefer a high inquiry-oriented science learning situation most frequently perform better than students who prefer a low inquiry-oriented situation in both the affective and cognitive domains when I.Q. is not considered and in just the affective domain when I.Q. is used as covariate, and 2) when each group is matched or not matched to their desired environment the four resultant groups perform differently, with the high-matched group usually performing best on all affective and cognitive instruments, the high-unmatched group performing second best on cognitive-oriented instruments, the low-matched group performing second best on attitude-oriented instruments, and the low-unmatched group usually performing poorest on all instruments. These findings parallel Hunt's (1974, p. 222) basic matching principle, "Low CL [conceptual level] learners profit more from high structure and high CL learners profit more from low structure or, in some cases, are less affected than low CL learners by variations in structure". The present study adds a major dimension to this finding by considering the affective domain. In this case the students matched with a low inquiry-oriented situation performed better than those students desiring, but not getting, a high inquiry-oriented situation.

Hunt's definitions of high conceptual level and low structure are assumed to be similar to the definitions used in the present study for high inquiry-orientedness.

The Matching Model and Inquiry-Oriented Instruction. When classrooms were checked to ascertain whether the students contained therein

predominantly preferred either high inquiry- or low inquiry-oriented instruction they were found to be predominantly heterogeneous (Table 32). However, when students were checked to see which teachers they had after being classified as matched or unmatched with either high or low inquiry-oriented environments, the students who claimed to be matched usually had one set of teachers and students who claimed to be unmatched had another set of teachers (Table 46). It appears some teachers adapt to a student's desired learning situation no matter what it is and others do not. The idea that teacher ability to adapt to student desires may be on a continuum was previously discussed and illustrated (Figure 4).

This finding of ability of teachers to adapt to a variety of student's desires constitutes a significant difference with respect to implications when compared with Hunt's matching model (1974, pp. 208-222). In Hunt's theory separate environments should be established to match the conceptual level of each student; in the present study teachers should be identified who can provide each student in a heterogeneous classroom with the learning situation he desires. In addition, a heterogeneous classroom may be desirable so a student will be exposed to a wider variety of inquiry-orientedness. The idea that heterogeneous classrooms are potentially desirable is based on three points: 1) present study findings that indicate students who desire a high inquiry-oriented science learning situation tend to perform better on both cognitive and affective measures 2) lack of evidence that students remain at a given level with respect to desire for inquiry-orientedness, and 3) the possibility of a student operating at a higher level of inquiry-orientedness is more likely

to occur in a heterogeneous classroom where various levels are in operation than in a homogeneous setting where a student is not only matched to, but locked into, the degree of inquiry-orientedness he desires at a particular time.

Affective and Cognitive Domains. The series of tests used to measure student attributes, appear, as a result of their correlations, to be measuring somewhat distinct characteristics. From the content of the tests it appears both affective and cognitive behaviors are represented as identified above. Science course objectives usually indicate instruction should be provided in both affective and cognitive domains; the present study identified instruments which may be useful in measuring these objectives.

The "Test on Scientific Attitudes" (Kozlow and Nay, 1976), one of the more thoroughly researched instruments, had one of the lowest discrimination abilities. One of the reasons could be that the curriculum in operation lacks inclusion of topics measured by this test. An objective of the present study was to identify instruments which would allow evaluation of student behaviors in areas other than that traditionally indicated by the "science mark". This test plus the others used in this study should be examined by teachers in relation to the objectives for their science courses and the science learning situations they provide.

Implications For Science Educators

The following points are recommended for consideration by science educators at all levels:

1. Areas other than the cognitive domain should be considered with respect to implications for instruction and evaluation. The present study identifies instruments which should be of use in expanding domains of evaluation and associated instructional methods. In addition, Alberta provincial norms at the grade nine level are provided for each test.

Not only do educators require a wide variety of instruments to measure student behaviors but provincial norms should be available on these instruments to aid in the consistency of student measurement throughout the province. That is, the teacher can not only check the achievement of his students but can compare his class results with norms indicative of the population. Feedback from this comparison can help the teacher identify areas in which the class may be particularly weak or strong. Such norms are of particular value to the many rural areas where class comparison with a larger population is difficult.

2. Educators should be aware of the different learning situations desired by individual students and attempt to accommodate them by having a wide variety of teaching strategies. An important prerequisite for this consideration is that the teacher know the individual student well. Considerable teacher interaction with small numbers of students could be one method of facilitating teacher knowledge of student science learning situation needs. As well, feedback from students can be obtained by use of instruments such as the "Science Learning Situation Inventory" which indicates the individual's desired science

learning situation and provides the teacher with information about his actual teaching mode characteristics.

Prerequisite to the above is the training of the teacher. Teachers should be trained to identify degrees of inquiry-orientedness desired by individual students. Individuals being prepared as science educators should be aware of the findings of the present study. As such, these individuals should have knowledge of, and practice with, the variety of teacher characteristics identified in the Science Learning Situation Inventory. Central to these instructional strategies is knowledge of and use of the process skills (Nay and Associates, 1971) (Appendix B). These skills form a particularly fertile area for practicing and implementing a variety of degrees of flexibility within a classroom. For example, one student may desire an experimental design which describes the procedure to be used in a series of numbered steps whereas a second student may wish to produce his own design; a continuum of degrees of student freedom exists between these two extremes. Similar situations exist for use of the other process skills and their use in totality. Implications for the practice of these skills extend to University courses teaching science or about science.

Teacher inservice provided by science consultants, supervisors or university personnel is subject to the same suggestions.

3. Since students who desire a high inquiry-oriented science learning situation perform better than students who desire a low inquiry-oriented situation, can any science learning activities be developed that motivate individuals to operate at a higher level of inquiry-orientedness?

Recommendations For Further Research

Research to provide answers to the following questions seems desirable. A suggestion regarding a possible research design follows each question.

1. Can students increase in their desire for a high inquiry-oriented science learning situation?

A pre- and post-test design could be used to investigate this question. Students could be given the SLSI-S questionnaire at the beginning of a science course and again at the end of it to ascertain any changes in their Desire (D) score. Instructors identified by their previous classes as being very perceptive as to student needs (low discrepancy scores) could be assigned to teach the classes (Figure 4).

2. Can teachers be taught to effectively utilize a variety of degrees of inquiry-orientedness? Is this an objective of present teacher training courses?

These questions could be treated as two separate research projects or combined.

To test the second question teacher training courses could be surveyed.

To test the first question teachers could be identified by use of the Science Learning Situation Inventory and those who receive large discrepancy scores take an in-service session designed to teach required instructional skills. These teachers could subsequently be tested by having their next classes again assign them discrepancy scores.

Agencies providing in-service training should perhaps use this technique to ascertain their efficacy.

3. *What function does and should the structure of the curriculum contribute to the degree of inquiry-orientedness of the classroom?*

Review of the literature indicated present curriculum contributes little to change a teacher's style of instruction. Therefore, this question is related to the previous one and suggests teacher in-service programs be designed to accompany curriculum implementation. The combination of an in-service program and a new curriculum could be researched as suggested for question two.

4. *Are degrees of desire for inquiry-orientedness related to I. Q. or Piagetian stages of development?*

The "Science Learning Situation Inventory" could be given to a set of classes along with tests identifying the Piagetian stages. In addition I. Q. tests could be administered. Correlations between pairs of variables should prove interesting.

5. *Is the desire for inquiry-orientedness related to age or grade level?*

The "Science Learning Situation Inventory" could be checked for grade level appropriateness and administered to the suggested grades. The proportion and degree of inquiry-orientedness desired at various grade levels could be ascertained.

6. *Are findings from this study true for other subject areas and grade levels?*

A parallel form of the "Science Learning Situation Inventory" could be developed and the design of the present study repeated. Instruments to measure student behaviors in the cognitive and affective domains would as in the present study, have to be identified or developed.

In addition to the above questions and research recommendations other suggestions may have potential. Further development of the instruments used in this study could contribute significantly to measurement in, particularly, the affective domain. SATS and TOUS should be further factor analyzed and normed since they appear to have potential in areas which require testing instruments. Much of the value of these tests may be in their factors.

The model (Figure 2) used in the present study could be used to guide further research with statistical analysis by factorial experiments to indicate interaction and main effects of the various SLSI-S subscores and, I. Q. or sex on the criterion measures. That is, more information may be obtained regarding interaction effects. A posteriori tests such as Scheffe Multiple Comparisons could follow. Studies of this type could take into consideration not only the high and low groups of students with respect to desire for inquiry-orientedness but refine the matching to a multi-grouped basis. For example, a certain score on SLSI-D could be used as a predictor instead of just the relative groupings used in the present study. That such matchings may be feasible is strongly indicated in the present study in that the two groups of students who were not matched with their desired science learning situation gave almost identical scores to their teachers.

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A P P E N D I C E S

APPENDIX A

CHARACTERISTICS OF AN INQUIRY-ORIENTED SCIENCE LEARNING SITUATION*

A. General Characteristics

1. A classroom where inquiry teaching and learning are taking place.
2. Varying degrees, numbers and combinations of the characteristics are possible, hence varying "levels of inquiry" teaching and learning occur.

B. Specific Characteristics

1. Nature of Student Activities
   a. Students work independently a good deal of the time, either singly or in groups.
   b. There is considerable student-student interaction.
   c. There is considerable questioning going on (of each other and the teacher).
   d. There is considerable use of process skills such as determining ways of solving a problem, hypothesizing, gathering data and making inferences. (Nay and Associates, Science Education, 1971, pp. 197-201.)
   e. Students operate at a higher cognitive level a good deal of the time: combine and/or transfer ideas, restructure knowledge, examine ideas critically, etc.

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*Prepared by M. A. Nay (1975) from a comprehensive survey of the literature on inquiry-oriented teaching.

2. Nature of Teacher Activities. The teacher

   a. Creates a free and open classroom climate, which however is continually under control.

   b. Circulates continuously among the students and gives individual attention to them.

   c. Motivates and stimulates students to pursue their own learning.

   d. Guides the learning of students and helps them to overcome difficulties.

   e. Is a resource person but does not give answers readily; guides students to sources of information.

   f. Does not act as an undisputed authority.

   g. Questions students a good deal of the time to evoke thought; generally will not accept a single answer if alternatives are possible.

   h. Pays attention to the development of acceptable affective behavior (attitudes, appreciations, etc.).

   i. Assesses student progress continually through observations, questioning, etc.

   j. Generally stays in the background when students are gainfully occupied.

3. Nature of the Curriculum and Instruction. With respect to curriculum and instruction:

   a. Less adherence is given to a prescribed program, and more attention given to the local environment and interests of students.

b. There is less emphasis on coverage of content and more emphasis on the open-ended aspect of topics being taken up.

c. There is more cooperative planning of work.

d. Appropriate emphasis is given to each major domain of child development: content, process skills, affective behavior and psychomotor skills.

e. Greater emphasis is placed on individualizing programs, coupled usually with independent study.

f. "Mind-stuffing", memorization and expository teaching (lecturing) are de-emphasized.

g. A proper balance is struck between conceptual learning (theory) and concrete experiences (practice).

h. The learning activities are less structured both by the teacher and the text, with more emphasis given to inquiry, inductive learning (discovery) and problem solving.

i. There is a greater variety of teaching-learning stimuli presented at an appropriate change of pace: lecturing, questioning, seatwork, experimentation, "inquiry into inquiry", use of process skills, use of multi-media, independent study, etc.

j. Classroom activities tend to involve the higher cognitive skills in Bloom's taxonomy.

k. More emphasis is given to the "process of scientific inquiry" underlying the concepts being studied.

l. The main concern is with thought processes rather than with correctness and answers or explanations.

m. *There is a greater tolerance of divergent views - dogmatism and authority are played down. However, students are encouraged to derive increasingly better answers or explanations by objective examination of data, exploring alternatives and gathering data relative to new aspects which have arisen.*

n. *Evaluation of student development covers the four major domains (point d above), the use of higher cognitive skills (point j above), and growth in skills such as questioning, working in group situations, independent study, etc.*

4. *Nature of the Classroom.*

   a. *The atmosphere is more free and democratic; discipline is RELAXED but not LAX.*

   b. *Students work in a variety of locations (library, laboratory, field, home, etc.).*

   c. *The "classrooms" are filled with a variety of instructional materials (pictorial, laboratory equipment, audio-visual aids, specimens, etc.).*

APPENDIX B

AN INVENTORY OF PROCESSES IN SCIENTIFIC INQUIRY*

by Dr. M. A. Nay, et al.

I. INITIATION

1. Identifying and defining a problem

   (a) speculating about a phenomenon
   (b) identifying variables
   (c) noting and making assumptions
   (d) delimiting the problem

2. Seeking background information

   (a) recalling relevant knowledge and experiences
   (b) doing literature research
   (c) consulting people

3. Predicting

4. Hypothesizing

5. Designing collection of data through field work and/or experimentation

   (a) defining the independent and control variables
   (b) defining the procedure and sequencing the steps
   (c) identifying needed equipment, materials and techniques
   (d) indicating safety precautions
   (e) devising the method for recording data

II. COLLECTION OF DATA

6. Procedure

   (a) collecting, constructing, and setting up the apparatus or equipment
   (b) doing field work and/or performing the experiment
   (c) identifying the limitations of the design (as a result of failures, blind alleys, etc.) and modifying the procedure (often by trial-and-error)
   (d) repeating the experiment (for reproducibility, to overcome limitations of initial design, and more)
   (e) recording data (describing, tabulating, diagramming, photographing, and so on)

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* M. A. Nay and Associates, "An Inventory of Processes in Scientific Inquiry," SCAT Bulletin 9: 12-16, 1970.

7. *Observing and observations*

   (a) *obtaining qualitative data (using senses)*
   (b) *obtaining semi-quantitative and quantitative data (measuring, reading scales, calibrating, counting objects or events, estimating, approximating)*
   (c) *gathering specimens*
   (d) *obtaining graphical data (charts, photographs, films, etc.)*
   (e) *noting unexpected or accidental occurrences (serendipity)*
   (f) *noting the precision and accuracy of data*
   (g) *judging the reliability and validity of data*

III. PROCESSING DATA

8. *Organizing the data*

   (a) *ordering to identify regularities*
   (b) *classifying*
   (c) *comparing*

9. *Representing the data graphically*

   (a) *drawing graphs, charts, maps, diagrams*
   (b) *interpolating, extrapolating, etc.*

10. *Treating the data mathematically*

   (a) *computing (calculating)*
   (b) *using statistics*
   (c) *determining the uncertainty in the results*

IV. CONCEPTUALIZATION OF DATA

11. *Interpreting the data*

   (a) *suggesting an explanation for a set of data*
   (b) *deriving an inference or generalization from a set of data*
   (c) *assessing validity of initial assumptions, predictions, and hypotheses*

12. *Formulating operational definitions*

   (a) *verbal*
   (b) *mathematical*

13. *Expressing data in the form of a mathematical relationship*

14. *Incorporating the new discovery into the existing theory (developing a "mental model")*

V. *OPENENDEDNESS*

15. *Seeking further evidence to*

    (a) *increase the level of confidence in the explanation or generalization*
    (b) *test the range of applicability of the explanation or generalization*

16. *Identifying new problems for investigation because of*

    (a) *the need to study the effect of a new variable*
    (b) *anomalous or unexpected observations*
    (c) *incompleteness ("gaps") and inconsistencies in the theory*

17. *Applying the discovered knowledge.*

APPENDIX C

INSTRUMENT USED FOR CLASSROOM VISITATIONS

BY EXTERNAL EVALUATORS

Inquiry Teaching

Instrument used and developed by
B. Galbraith and G. Gay
University of Alberta

Third Draft

Teacher ____________________

Date ____________ Topic ________

Date ____________ Topic ________

Observer ____________________

I. Description of Classroom Operation

	COMMENTS
A. Percentage of time spent in lectures and classroom discussions. 1 2 3 4 5 NA	1 ... 0 to 10% 2 ... 11 to 20 3 ... 21 to 40 4 ... 41 to 60 5 ... 61 to 100
B. 1. During the time indicated in A., what percentage of the talk is teacher talk? 1 2 3 4 5 NA	1 ... 0 to 50% 2 ... 51 to 65 3 ... 66 to 80 4 ... 81 to 90 5 ... 91 to 100
2. Teacher talk directed at the entire class causes inquiry activity on the part of the students. (i.e. teacher-talk emphasizes student use of cognitive skills). 1 2 3 4 5 NA	1 - Students become engaged in inquiry centered about their own question. 2 - Students become engaged in inquiry centered about teacher questions. 3 - Students attend to teacher inquiry. 4 - Students attend to teacher exposition. 5 - Students ignore teacher-talk.

	COMMENTS
C. 1. Percentage of teacher talk for teacher interactions with individuals and small groups. 1 2 3 4 5 NA (Same scale as B.1.)	The following comment may be used as a weighting factor in evaluating the importance of C. 1. and C. 2.: Approximate percent of time teacher spends interacting with individuals or groups ... _____
2. Teacher talk directed at the small groups causes inquiry activity. 1 2 3 4 5 NA (Small scale as B.2.)	
D. The teacher delegates responsibility for obtaining equipment, performing demonstrations, operating equipment etc. rather than doing everything himself. 1 2 3 4 5 NA delegates responsibility — does not delegate responsibility	3 - The teacher delegates the job of handling equipment but supervises closely.
E. Students are involved in exchanging and challenging each other's data, ideas, hypotheses, procedures, data processing, inferences, etc. (i.e. a natural activity) 1 2 3 4 5 NA high interaction — low interaction	1 - All ideas subject to group criticism. 3 - Some ideas exchanged and criticized. 5 - No exchange of ideas.

	COMMENTS
F. The teacher exemplifies in his classroom behavior the kind of inquiry he wishes his students to display. 1 2 3 4 5 NA	1 - The teacher demonstrates a critical attitude towards all aspects of inquiry. 3 - The teacher demonstrates a critical attitude towards particular inquiry skills for occasional emphasis. 5 - The teacher is non-critical and haphazard in his use of inquiry skills.
G. Classroom organization and management are conducive to inquiry. 1 2 3 4 5 NA conducive limiting	1 - The learning environment is structured in such a way as to enable and encourage critical inquiry. 3 - The learning environment provides partial support for the involvement of students in critical inquiry. 5 - The learning environment lacks a structure to support and encourage critical inquiry.
II. <u>Emphasis on and Student Involvement in Specific Inquiry Skills</u> (Processes) (Taba, Brandwein - Students should come to accept responsibility for ...) A. Formation of hypotheses 1. Development of hypotheses is given significant attention as a step in problem investigation. 1 2 3 4 5 NA subject to critical attention omitted	1 - Subject to critical attention. 3 - Understood by students. 5 - Ignored.

	COMMENTS
2. Students are involved in development of hypotheses. 1 2 3 4 5 NA	1 - Process undertaken independently by students (S). 2 - Process undertaken cooperatively, student dominant (ST). 3 - Process undertaken cooperatively. 4 - Process undertaken cooperatively, teacher dominant (TS). 5 - Given to the students by the teacher (T). (Hereafter these points will be referred to by using the letters in parentheses only.)
B. Development of procedures and experimental designs. 1. Experimental design is given significant attention. 1 2 3 4 5 NA	1 - Subject to critical attention. 2 - Understood by students. 5 - Ignored.
2. Students are involved in the development of an experimental design and specific procedures. 1 2 3 4 5 NA S ST TS T	(Note: B.2., C.2., D.2., and E.2. follow the pattern of A.2.)
C. Data Collection 1. Collection of data is given significant attention. (Completeness and accuracy are stressed and sufficient time is alloted.) 1 2 3 4 5 NA	1 - Subject to critical attention. 3 - As required by the investigation. 5 - Ignored. % of time spent in collecting data and related activities = ______

	COMMENTS
D. Data Processing 1. Processing of data is given significant attention. 1 2 3 4 5 NA emphasized omitted	1 - Subject to critical attention. 3 - Some form of data processing used. 5 - No data processing.
2. Students process their data on their own. 1 2 3 4 5 NA S ST TS T	3 - Students process data by a procedure determined by their teacher. 5 - Data processing is done by teacher.
E. Conceptualization of Data 1. Interpretation of data is given significant attention. 1 2 3 4 5 NA	1 - Data interpreted critically. 3 - Data interpreted non-critically. 5 - Data not interpreted.
2. Students interpret their data on their own. 1 2 3 4 5 NA S ST TS T	3 - Interpretations restricted to answering highly specific teacher or textbook questions.
F. Open Endedness 1. The student is encouraged to work towards his own answer to a problem rather than a given "correct" answer. 1 2 3 4 5 NA no final answer answer predetermined	2 - Students to form individual conclusions. 3 - Concensus to be reached after investigation.

	COMMENTS
2. The student is encouraged to follow up his own ideas for further investigations and to apply what he has learned in new ways. 1 2 3 4 5 NA activity encouraged — activity restricted	1 - Independent activity in class is encouraged. 3 - Independent activities are permitted after school, but not in class except by specific request. 5 - Independent activity is not permitted.
III. Teacher Guidance in Use of Inquiry Skills A. Teacher-asked and teacher written questions exemplify to the student the sorts of questions he must ask of the materials he studies and to find the answers he seeks. (i.e. to design suitable experiments and to process and interpret data, viz. cause inquiry.) 1 2 3 4 5 NA frequently — seldom	1 - The teacher asks skills questions only. 3 - The teacher asks knowledge-questions as often as he asks skills questions. 5 - The teacher asks questions of knowledge only.
B. Student problems are dealt with by giving guidance and allowing time for students to reflect and weigh alternatives rather than by giving an immediate "correct" answer. 1 2 3 4 5 NA guidance only — answers only	1 - The teacher asks guiding questions and encourages students to find their own answers. 3 - The teacher asks questions which clearly lead to a single "correct" answer. 5 - Answers provided immediately.

	COMMENTS
C. The sequence of problems and the approach to the problems is highly structured. 1 2 3 4 5 NA flexible ... completely structured	1 - Structure dependent on teacher-student interaction. 3 - Students conform to a relatively open structure. 5 - Students follow directions only.
D. Students are encouraged to carry out investigations with a minimum of teacher dependence. (independent learning) 1 2 3 4 5 NA complete independence ... complete independence	1 - Students work independently on given problems. 3 - Students work on problems according to procedures described by textbook or assignment sheets. 5 - All activities are directed by the teacher.
IV. <u>Use of Teaching Techniques and Materials</u> A. The teacher uses a wide variety of approaches to teaching and a wide variety of sources of information. (i.e. techniques and materials) (eg. varied use of discussions, films, field trips, labs, library research, etc.) 1 2 3 4 5 NA many ... only one	Quantity.
B. The approaches used are appropriate for the development of inquiry in the particular topic. 1 2 3 4 5 NA appropriate ... inappropriate	Quantity.

	COMMENTS
C. The approaches used are applied in such a way as to maximize their effectiveness in developing student inquiry. 1 2 3 4 5 NA inquiry maximized ... inquiry restricted	Used appropriately.

INDEX OF INQUIRY

1. I. A. .... ____

2. I. (B1 + C1)/2 = (____ + ____)/2 .... ____

3. I. (B2 + C2)/2 = (____ + ____)/2 .... ____

4. I. D. .... ____

5. I. E. .... ____

6. I. F. .... ____

7. I. G. .... ____

8. II. (A1 + B1 + C1 + D1 + E1)/5
   = (____ + ____+ ____+ ____+ ____)/5 .... ____

9. II. (A2 + B2 + C2 + D2 + E2)/5
   = (____ + ____+ ____+ ____+ ____)/5 .... ____

10. II. (Enter 9 again) .... ____

11. II. F1 .... ____

12. II. F2 .... ____

13. III. A .... ____

14. III. B .... ____

15. III. C .... ____

16. III. D .... ____

17. IV. (A + B)/2 = (____ + ____)/2 .... ____

18. IV. C .... ____

TOTAL .... ____

Standard Index of Inquiry Score = (Total*10)/(18 - NA)
= (_____*10)/(18 - ____) = ... ____

Interpretation

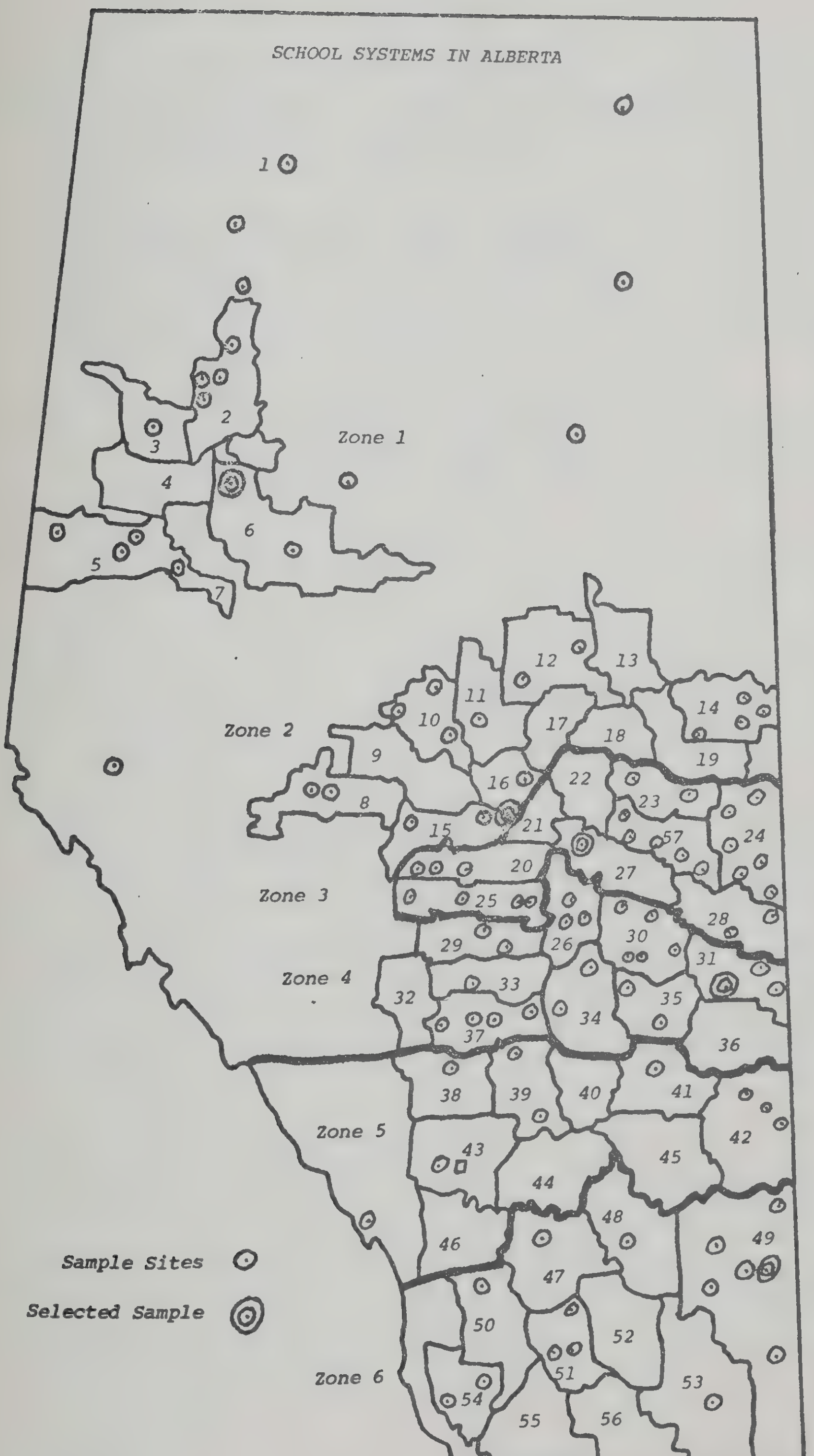
10 --- highest inquiry score
30 --- central score
50 --- lowest inquiry score

APPENDIX D

STATEMENTS TO WHICH THE STUDENTS RESPONDED IN IDENTIFYING TMC IN THE PILOT STUDY

1. We spend more time working and doing things than the science teacher actually does teaching.
2. We get to study topics that are of interest to us.
3. There are definite answers or conclusions to our experiments or lab work.
4. When we have a science problem the teacher gives us the correct answer right away.
5. Our science teacher uses many types of teaching. (e.g., discussion groups, films, overhead projectors, lab exercises, etc.)
6. We perform a large variety of activities in our science class, e.g., listen to the teacher, solve problems, do lab work, work in the library, watch movies, discuss our work with other students, etc.
7. We perform studies or parts of studies on our own with no help from the science teacher.
8. We perform lab work in which we do not know if there is a correct answer before we begin.
9. Our science teacher starts a new study by giving rules and general ideas.
10. We learn about and practice the type of attitudes a scientist should have.

APPENDIX E



1. Fort Vermilion
2. Peace River
3. Fairview
4. Spirit River
5. Grande Prairie
6. High Prairie
7. East Smoky
8. Yellowhead
9. Lac Ste. Anne
10. Barrhead
11. Westlock
12. Athabasca
13. Lac La Biche
14. Bonnyville
15. Parkland
16. Sturgeon
17. Thorhild
18. Smoky Lake
19. St. Paul
20. Parkland
21. Strathcona
22. Lamont
23. Two Hills
24. Vermilion River
25. Leduc
26. Camrose
27. Beaver
28. Wainwright
29. Ponoka
30. Flagstaff
31. Provost
32. Rocky Mtn. House
33. Lacombe
34. Stettler
35. Paintearth
36. Neutral Hills
37. Red Deer
38. Mountainview
39. Three Hills
40. Starland
41. Rangeland
42. Acadia
43. Calgary 41
44. Wheatland
45. Drumheller
46. Foothills
47. Vulcan
48. Newell
49. Medicine Hat
50. Willow Creek
51. Lethbridge
52. Taber
53. Forty Mile
54. Pincher Creek
55. Cardston
56. Warner
57. Minburn

APPENDIX F

DIRECTIONS

YOUR TEACHER NUMBER IS ________

1. Six questionnaires or "tests" are included in the student booklet. You may have the students write as many as are feasible in the time periods you have.

   a. Please collect and keep together all answer sheets for each separate test. Stamped, self-addressed envelopes are included for each set of answer sheets. After each complete set of answer sheets is handed in, please put them into the envelope and mail.

   b. If a student does not complete a test in the time period allotted, you may collect the answer sheet and return it during the next testing period so he may complete it.

   c. Please collect all test booklets at the end of each testing period.

2. Please tell the student your identification number and assign each of them a number.

   a. Teacher I.D. numbers will be changed when data is reported so anonymity is preserved.

3. Please read the instructions on the front of the test booklet with the students and help them fill in the information called for at the top of the page. Also insure they are using HB pencils.

4. Later STEP tests will be sent and Science marks and I.Q.'s will be requested.

5. If you require additional information please write

   Gary Gay,
   9913B Richmond Avenue,
   Grande Prairie, Alberta,
   T8V 0V1,

   or phone 532-0155 in Grande Prairie collect.

   Thank you for your cooperation.

SCIENCE ATTRIBUTE INSTRUMENTS

Enclosed in this booklet are several tests or questionnaires having to do with different aspects of science such as what you like or don't like about it.

1. All the "tests" or questionnaires will be answered on special separate answer sheets using HB pencils only. Please do not write on the test booklet.

2. You will use separate answer sheets for each "test". They can be obtained from your teacher.

3. On the top of each answer sheet please put:

   a. Your name (and the number your teacher has assigned you).
   b. The name of the test.
   c. Your teacher's name.

4. Please fill in the box in the upper right-hand corner in the following manner:

   a. The first blank: put the number corresponding to the name of the test you are writing. See the list below:

      1) SLSI 1
      2) TOUS - Form Ew 2
      3) HIFAMS 3
      4) SATS 4
      5) TOUS - Form Jw 5
      6) Test on the Nature of Science 6

   b. Put your student number (as assigned by your teacher) in the next two blanks. If your number is less than 10, please precede it with a 0. e.g. 7 would be recorded as 07. Please keep the same number for all "tests" or "questionnaires".

   c. Put your teacher number in the last three blanks. If your teacher number is less than 10, precede it with 2 zeros; if it is greater than 10 but less than 100, precede it with one zero.

      e.g. If you are writing the TOUS - Form Ew test, your student number is 9, and your teacher number is 138, the box in the upper right hand corner would appear as follows:

		STUDENT NUMBER									
Test Number ...... (	2	=0=	=1=	~~=2=~~	=3=	=4=	=5=	=6=	=7=	=8=	=9=
(	0	~~=0=~~	=1=	=2=	=3=	=4=	=5=	=6=	=7=	=8=	=9=
Student Number ... (	9	=0=	=1=	=2=	=3=	=4=	=5=	=6=	=7=	=8=	~~=9=~~
(	1	=0=	~~=1=~~	=2=	=3=	=4=	=5=	=6=	=7=	=8=	=9=
Teacher Number ... (	3	=0=	=1=	=2=	~~=3=~~	=4=	=5=	=6=	=7=	=8=	=9=
(	8	=0=	=1=	=2=	=3=	=4=	=5=	=6=	=7=	~~=8=~~	=9=

5. After you have finished a "test" or questionnaire, please hand in the answer sheet to your teacher and get another one if he or she wants you to go on with the next questionnaire.

6. The colored pages indicate the end of each questionnaire or test.

Thank you for your cooperation.

Gary Gay, Education Consultant
(Science)
Department of Education
9913B Richmond Avenue
Grande Prairie, Alberta.

NUMBER 1 - SLSI

SCIENCE LEARNING SITUATION INVENTORY (SLSI)

Following are descriptions of several science learning situations. After each description are two or three questions of the following types:

1. *I would like to be in such a situation.*

2. *Time is spent doing this in class.*

3. *I get to do this.*

The answers to these questions are meant to indicate the type of science class you would like to be in and the type of science class you are in.

Example: Glass bending is taught in many schools.

1. *I would like to be in such a school.*

2. *We spend considerable time talking about glass bending in our school.*

3. *I get to spend considerable time bending glass.*

On the specially prepared answer sheet, for each question mark

A. *If you strongly agree with the statement.*

B. *If you agree with the statement.*

C. *If you neither agree nor disagree.*

D. *If you disagree with the statement.*

E. *If you strongly disagree with the statement.*

Please fill in the information asked for on the top of the answer sheet and put your teacher's name in the top right-hand corner.

The situations and questions start on the next page. This is not a test and you will not be timed, proceed when you are ready.

Key:	A	B	C	D	E
	strongly agree	agree	neutral	disagree	strongly disagree

In some science classes the teachers spend most of the time telling the students about science or lecturing to them.

1. *I would like to be in that type of class.*
2. *I am in that type of class.*

In some science classes the science teacher causes the students to think when he talks to them.

3. *I would like to be in that type of class.*
4. *I am in that type of class.*

In some science classes the teacher exemplifies or acts like a scientist would act when he is confronted with a problem.

5. *I would like to be in that type of class.*
6. *I am in that type of class.*

Some science classrooms are organized in such a way that a lot of time is available for students to perform investigations.

7. *I would like to be in that type of class.*
8. *I am in that type of class.*

Some science teachers are like scientists in the way they do things.

9. *I would like my science teacher to be like that.*
10. *My science teacher is like that.*

When you ask some science teachers a question you get questions in return, others supply the answer immediately.

11. *I would like a science teacher that gives an immediate direct answer.*
12. *I have a science teacher that gives an immediate direct answer to my questions, rather than one who asks questions which lead to the answer.*

Key:	A	B	C	D	E
	strongly agree	agree	neutral	disagree	strongly disagree

In some classes a wide variety of techniques are used to solve problems in science and to learn about science. (Examples: discussions, field trips, lectures, movies, lab, library, etc.)

13. *I would like to be in such a class.*

14. *I am in such a class.*

15. *The approaches my teacher uses to teach me about science are very effective.*

Some science classes spend considerable time learning about the types of attitudes a scientist should have.

16. *I would like to be in such a class.*

17. *I am in such a class.*

In some science classes the students help set up equipment for demonstrations and assist in performing them.

18. *I would like to be in such a class.*

19. *I am in such a class.*

Some science classes spend time developing hypotheses or guessing possible answers to a given problem.

20. *I would like to be in such a class.*

21. *Our class does spend time developing hypotheses.*

22. *I spend time developing hypotheses.*

Some science classes spend time designing experiments which could be used to help find the solution to a given problem.

23. *I would like to be in such a class.*

24. *Our class does spend time designing experiments.*

25. *I spend time designing experiments.*

Key:	A	B	C	D	E
	strongly agree	agree	neutral	disagree	strongly disagree

Some science classes spend time collecting data which may be of use in solving a particular problem.

26. I would like to be in such a class.

27. We do spend time collecting data in our class.

28. I get to spend time collecting data in my class.

Some science classes spend time organizing, analyzing and interpreting data collected in a given experiment.

29. I would like to be in such a class.

30. We do spend time organizing, analyzing and interpreting data in our class.

31. I spend time organizing, analyzing and interpreting data.

In some science classes the student is expected to work towards his own answer to a scientific problem rather than a "correct" answer which the teacher expects.

32. I would like to be in such a class.

33. I am in such a class.

In some science classes students get to choose their own experiments at least part of the time.

34. I would like to be in such a class.

35. I am in such a class.

In some science classes students are motivated to discuss collected data, ideas, hypotheses, procedures, data processing, etc. with other students.

36. I would like to be in such a class.

37. I am in such a class.

Respond to each of the following statements by marking

A	B	C	D	E
if you <u>strongly agree</u> with it.	if you <u>agree</u> with it.	if you are neutral.	if you <u>disagree</u> with it.	if you <u>strongly disagree</u> with it.

38. We spend more time working and doing things than the science teacher actually does teaching.

39. We get to study topics that are of interest to us.

40. There are definite answers or conclusions to our experiments of lab work.

41. When we have a science problem the teacher gives us the correct answer right away.

42. Our science teacher uses many types of teaching. (e.g., discussion groups, films, overhead projectors, lab exercises, etc.)

43. We perform a large variety of activities in our science class. E.g., listen to the teacher, solve problems, do lab work, work in the library, watch movies, discuss our work with other students, etc.

44. We perform studies or parts of studies on our own with no help from the science teacher.

45. We perform lab work in which we do not know if there is a correct answer before we begin.

46. Our teacher starts a new study by giving rules and general ideas.

47. We learn about and practice the type of attitudes a scientist should have.

48. We learn science in a manner similar to the way in which scientists learn about science.

Key:	A	B	C	D	E
	strongly agree	agree	neutral	disagree	strongly disagree

49. As a result of learning science I understand better what scientists are doing in the world today.

50. As a result of learning science I am more interested in the latest developments of science as reported in newspapers or magazines.

51. I spend time on my own outdoors or at home collecting data or information that is of interest to me in science.

52. In class we often analyze current newspaper or magazine articles to see what the scientists are actually planning and doing.

53. When I read articles in newspapers and magazines or hear news about scientists on the radio I think about what stage of planning their experiments are in.

54. We spend time in class just investigating the activities scientists participate in rather than just the knowledge they discover.

55. I view the lab, the classroom, the library, outside the school and other teachers all as possible sources of information for my science studies.

56. We learn, in our science classes, desirable ways to attack new scientific problems.

57. I know why scientists are going to the moon.

58. As a result of studying science I believe I know, and know how to perform, the important steps in solving a scientific problem.

59. I would attack and propose a solution to a new problem using a scientific method.

Key:	A	B	C	D	E
	strongly agree	agree	neutral	disagree	strongly disagree

60. As a result of the manner in which our class studies science I feel as if I'm acting like a scientist a large proportion of the time.

61. As I study science I feel I am learning a method I can use to study and solve new science and personal problems which may arise.

62. Our science class often spends considerable time discussing the results of experiments with little advise from the teacher.

Thank you for your cooperation in filling in this Science Learning Situation Inventory.

NUMBER 2 - TOUS - Ew

TOUS

FORM Ew

TEST ON UNDERSTANDING SCIENCE

DIRECTIONS

1. Each of the questions or incomplete statements in this booklet is followed by four possible answers. You are to choose the one BEST answer for each question.

2. All of your answers are to be made on the separate answer sheet you have been given. Do not make any marks in this booklet.

3. Indicate your answers on the answer sheet by completely BLACKENING the box which has the same capital letter as the answer you have chosen. You may use a regular pencil to make your marks. However, do not use a fountain pen, ball point pen, or colored pencil.

4. You are to mark one, and only one, answer for each question. If you change your mind about an answer, erase it completely and cleanly. Be sure to make your new mark heavy and dark.

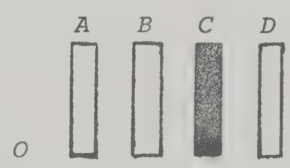
   Here is an example:

---

0. The main reason for doing experiments in science is to

   A. check ideas.
   B. find things out.
   C. use equipment.
   D. learn about nature.

ANSWER SHEET



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5. Imagine that the right half of the above example is a small piece of your separate answer sheet. Look at row "0" on this "midget" answer sheet. In the example, answer box C has been blackened. This means that the person thinks that the main reason for doing experiments in science is to use equipment. Your answers for all the questions in this booklet should be marked in this manner on your separate answer sheet.

6. Be sure that the number of the row you are marking and the number of the question you are answering are the SAME. If you have any questions about these directions, raise your hand. Your teacher will try to help you.

7. *Try hard to answer all of the questions in this booklet.*

8. *Once again, DO NOT WRITE ANYTHING IN THIS QUESTION BOOKLET.*

Please do not turn this page until you are asked to do so.

1. Let's compare scientists and magicians. Which one of the following sentences is best?

   A. Scientists and magicians both try to explain things.
   B. Scientists and magicians both try to make things mysterious.
   C. Magicians try to explain things, but scientists make them mysterious.
   D. Scientists try to explain things, but magicians make them mysterious.

2. Scientific discoveries have come from

   A. almost all countries of the world.
   B. only countries with big industries.
   C. only countries with large populations.
   D. almost all countries in Africa and Asia.

3. George said: "A scientist's work never ends". By this George means that

   A. the work day in a laboratory is very long.
   B. people ask scientists many different questions.
   C. scientists need more help in their research.
   D. new questions come up whenever a problem is solved.

4. When a scientist finishes a research project, he will usually

   A. keep his results secret to help his country.
   B. let other scientists know about his findings and ideas.
   C. use his results in an invention for industry.
   D. ask the government for permission to write a report.

5. Scientists today agree on many ideas about how the natural world works. Most likely, these ideas will

   A. be changed when scientists have more information.
   B. not be changed for a very long time to come.
   C. be changed to keep up with fast-moving world events.
   D. not be changed because they are scientific ideas.

6. Today, the education of Canadian scientists who teach and do research at colleges and universities generally

   A. is completed after four years of college attendance.
   B. includes a period of practical training in some industry.
   C. is completed after two years of college or technical school.
   D. includes long study in universities after finishing college.

7. *Phil said: "Machines are taking over so much of our work that they will some day replace scientists." Phil's statement is wrong because*

   A. *machines cannot build other machines.*
   B. *men cannot let machines take over the world.*
   C. *men cannot let machines run by themselves.*
   D. *machines cannot think up new ideas.*

8. *When a scientist has a day off, he would probably not like to*

   A. *go to his laboratory.*
   B. *spend some time on his hobby.*
   C. *go to a friend's party.*
   D. *spend some time with his family.*

9. *The scientists of today can work on more complex problems than the scientists of the past mainly because they*

   A. *work much harder than earlier scientists.*
   B. *have more ideas than earlier scientists.*
   C. *build on the work of earlier scientists.*
   D. *are more clever than earlier scientists.*

10. *Most important scientific ideas are developed today as a result of*

   A. *a long study by a scientist working alone.*
   B. *work and thinking carried on by many scientists.*
   C. *team-work between scientists and the government.*
   D. *a group of scientific experts deciding what to study.*

11. *In observing and experimenting, a scientist today almost always needs*

   A. *computers and other large machines.*
   B. *many trained people to help him.*
   C. *microscopes, telescopes, and test tubes.*
   D. *different kinds of special equipment.*

12. *Scientists are often said to be very hardworking and quite devoted to their jobs. This is true of*

   A. *successful people in almost all kinds of work.*
   B. *scientists, but not people in other kinds of work.*
   C. *most people in important work, but not scientists.*
   D. *more scientists than people in other kinds of work.*

13. When many new facts are discovered which do not fit a scientific theory, scientists will usually ask themselves:

    A. Shall we throw out the theory since the facts do not fit it?
    B. Can we change the facts a little so that they will fit the theory?
    C. Shall we keep the theory as it is, since these new facts don't help it?
    D. Can we change the theory a little so that these new facts will fit in?

14. Scientists are most likely to make important discoveries by

    A. making many observations.
    B. trying out ideas.
    C. reading about experiments.
    D. asking many questions.

15. Before a scientist announces a new theory to the public, he will most likely talk his ideas over with

    A. other scientists in his special field.
    B. newspaper reporters who write about science.
    C. a group of experts on scientific theories.
    D. government leaders interested in his theory.

16. Which of the following sentences about science is best?

    A. Modern science is too advanced to use past discoveries.
    B. Modern science develops modern products.
    C. Modern science depends on useful inventions.
    D. Modern science is based on the science of the past.

17. The main reason that Canadian scientists are asking for much money for research is that

    A. as much money should be spent on scientific work as on other things.
    B. many scientific projects take a long time and need much equipment.
    C. the cost of scientific materials and equipment has gone up since 1945.
    D. new scientific laboratories must be large and are expensive to build.

18. When a scientist reads a report of a new scientific discovery, he will probably

    A. not fully believe the report until he has checked the work himself.
    B. believe the report without asking too many questions about it.
    C. not fully believe the report until he has obtained more information.
    D. believe the report because it describes the work of scientists.

19. Scientists make many measurements in their work. Of the following, a scientist would be most likely to measure

    A. how many germs a certain toothpaste kills.
    B. the biggest load that a bridge can carry safely.
    C. how far a bird flies south for the winter.
    D. the distance a car runs on one gallon of gasoline.

20. Mary likes science. At first, she did not like to write down all the details of her experiments. If Mary becomes a scientist, however, this training will help her to

    A. be patient in doing her experiments.
    B. make better reports about her experiments.
    C. develop theories from her experiments.
    D. think up new experiments to perform.

21. Different groups of people help mankind in different ways. What is the special way in which scientists help mankind?

    A. Scientists make better things for better living.
    B. Scientists show us how to be more healthy.
    C. Scientists give us knowledge about nature.
    D. Scientists offer skilled service and advice.

22. When a scientist completes a new scientific theory, we know that he has

    A. created one of the laws of nature.
    B. helped bring mankind closer to the truth.
    C. discovered new ways of experimenting.
    D. developed new ideas and understandings.

23. The newest microscopes make it possible for scientists to study very small objects and also to

    A. explore many new problems.
    B. look for the meaning of life.
    C. observe atoms in motion.
    D. see that germs cause disease.

24. A scientific law describes

    A. rules which scientists must obey.
    B. rules which connect events in nature.
    C. rules for doing good experiments.
    D. good guesses about how things happen.

25. Which one of the following sentences best describes science?

    A. Science is experimenting.
    B. Science is planning and thinking.
    C. Science is thinking and doing.
    D. Science is observing and measuring.

26. A scientist is open-minded about his work if he

    A. discusses most of his ideas with others.
    B. considers ideas which go against his own.
    C. thinks up many new ideas for experiments.
    D. agrees with the ideas of other scientists.

27. Scientists study plants mainly to

    A. help farmers to produce more food.
    B. discover how to make new medicines.
    C. understand how they live and grow.
    D. find out where they will grow best.

28. Which of the following is the main need of science?

    A. People with new ideas.
    B. More money and equipment.
    C. Well-trained workers.
    D. Better working conditions.

29. When we say that a scientist has formed a <u>hypothesis</u> about an experiment, we mean that he has

    A. indicated which measurements were made.
    B. designed equipment needed for the experiment.
    C. described how the experiment turned out.
    D. made a careful guess about what will happen.

30. Which of the following is the best list of what scientists study?

    A. Atoms, molecules, and stars.
    B. Matter, energy, and living things.
    C. Living things, disease, and growth.
    D. Rockets, satellites, and space travel.

31. Bill always gets good grades in school, likes to build model airplanes, and plays jokes on his classmates. Frank gets high grades in arithmetic, likes to read books, and plays baseball. Janet is serious and smart, and likes to dance. Who do you think could become a scientist?

    A. Bill.
    B. Frank.
    C. Janet.
    D. Any one of the three.

32. Should a person who makes plans to build new types of airplanes be called a scientist?

    A. Yes, because he uses scientific methods in his plans.
    B. No, because he is planning to build a useful machine.
    C. Yes, because he does experiments to check his plans.
    D. No, because he is planning to try out some new ideas.

33. A scientific <u>theory</u> should

    A. provide the final answer to scientific questions.
    B. supply directions for making useful things.
    C. tie together and explain many natural events.
    D. suggest good rules for carrying out experiments.

34. When a scientist makes a new discovery, he usually makes a report of it. He does this because he

    A. hopes other scientists will help him to finish his work.
    B. wants other scientists to learn about his work and check it.
    C. hopes to help his fellow man by announcing his discovery.
    D. wants to know if others have done the same work and have reported it.

35. Experiments are used in science to

    A. solve the problems of man.
    B. find out the truth about nature.
    C. try out the ideas of scientists.
    D. prove that the universe is orderly.

36. "Most scientists are smart. They learn more easily than most people and can do harder things with their minds." Is this statement correct?

    A. Yes, but scientists are generally no smarter than doctors or lawyers.
    B. Yes, but only because scientists are born with scientific skills.
    C. Yes, but only because scientists have received special training.
    D. No. Scientists are about as smart as most people but no smarter.

This is the end of the questions in this booklet. If you finish before time is called, please go back and check your answers.

NUMBER 3 - HIFAMS

HOW I FEEL ABOUT MY SCHOOL

Originally Developed by

J. K. Coster

And Modified by Gary Gay

I am conducting a survey of the opinion, beliefs, and feelings of several junior high school students like yourself. I would like to find out how you feel and what you think about your school. Your answers to the questions will provide us with information which will help us in improving our schools.

This is NOT a test. There are no right answers. YOUR OPINIONS OR ANSWERS ARE THE ONES IN WHICH I AM INTERESTED AND THE ONES THAT I WANT. I would like you to be very frank in making your selections.

The questionnaire consists of forty-two questions about many aspects of your school. Following each question is a list of five possible answers. Please read each question carefully. Then carefully read ALL five answers and select the ONE answer with which you agree most fully. (If none of the possible answers exactly express your opinion, you are asked to select the answer that most nearly expresses it.) After you have made your selection, mark the answer sheet option corresponding to your choice of answers. (Do not write on this paper).

EXAMPLE:

140. On the average, is Alaska warmer or colder than Hawaii?

A. Alaska is much warmer than Hawaii.
B. Alaska is slightly warmer than Hawaii.
C. Alaska is neither warmer nor colder than Hawaii.
D. Alaska is slightly colder than Hawaii.
E. Alaska is much colder than Hawaii.

140.	A 1	B 2	C 3	D 4	E 5
	----	----	----	----	----
	----	----	----	----	----

Option E will probably be your choice for this example; practice answering by darkening the space between the lines of option E, item number 140 on the answer sheet. Use only an HB pencil and erase completely any answers you wish to change.

Please put your name and your school's name on the answer sheet and, in addition, put your teacher's name in the top right hand corner.

HOW I FEEL ABOUT MY SCHOOL

1. I am

   A. A boy
   B. A girl

2. Do you believe that the work that you are taking in junior high school will be useful to you after you leave junior high school?

   A. Yes! I am certain that my junior high school work will help me a great deal.
   B. I feel that my junior high school work generally will be useful.
   C. I feel that my junior high school work will be of <u>some</u> use to me.
   D. I feel that my junior high school work will be of <u>little</u> use to me.
   E. No! I am certain that my junior high school work will be of NO use to me.

3. We spend more time working and doing things than the science teacher actually does teaching.

   A. This <u>almost never</u> happens.
   B. This seldom happens.
   C. This sometimes happens. (about half the time)
   D. This often happens.
   E. This <u>almost always</u> happens.

4. Do you feel that your teachers treat you fairly?

   A. Yes! My teachers <u>always</u> treat me fairly.
   B. My teachers usually treat me fairly.
   C. Sometimes my teachers treat me fairly; sometimes they don't.
   D. My teachers usually do NOT treat me fairly.
   E. No! My teachers <u>never</u> treat me fairly.

5. *What is your opinion of your chances of getting the kind of job that you would like to have after you leave high school (or college, if you plan to attend)?*

   A. *I feel that I have a very poor chance of getting the kind of job I want.*
   B. *I feel that I have a poor chance of getting the kind of job I want.*
   C. *I feel that my chances are about average.*
   D. *I feel that I have a good chance of getting the kind of job I want.*
   E. *I feel that I have an excellent chance of getting the kind of job I want.*

6. *How interesting, do you feel, is your school work to you?*

   A. *All of my school work is interesting to me.*
   B. *Most of my school work is interesting to me.*
   C. *About half of my school work is interesting to me.*
   D. *Little of my school work is interesting to me.*
   E. *None of my school work is interesting to me.*

7. *We get to study topics that are of interest to us.*

   A. *This almost always happens.*
   B. *This often happens.*
   C. *This sometimes happens. (about half the time)*
   D. *This seldom happens.*
   E. *This almost never happens.*

8. *What is your opinion of the working and studying conditions in your junior high school?*

   A. *Our working and studying conditions are very poor! They couldn't be worse!*
   B. *I feel that they are poor.*
   C. *I feel that they are about average.*
   D. *I feel that they are good.*
   E. *Our working and studying conditions are excellent! They couldn't be better.*

9. *Do you feel that the other students in your school like you?*

   A. *No! I feel that NONE of the other students in my school like me.*
   B. *I feel that only a few of the other students like me.*
   C. *Some of the other students like me; some don't.*
   D. *I feel that most of the other students like me.*
   E. *Yes! I feel that ALL of the other students in my school like me.*

10. *What is your general feeling of the junior high school that you are now attending?*

    A. *There is no other school that I would like as well as this one.*
    B. *Generally, I am satisfied with my school.*
    C. *I feel that this is an average school.*
    D. *Generally, I am NOT satisfied with this school.*
    E. *I feel that this is the worst school that I could attend.*

11. *There are definite answers or conclusions to our experiments or lab work.*

    A. *The described situation almost never happens.*
    B. *The described situation seldom happens.*
    C. *The described situation sometimes happens. (about half the time)*
    D. *The described situation often happens.*
    E. *The described situation almost always happens.*

12. *Do you believe that your parents are interested in your junior high school work?*

    A. *Yes! I am sure that my parents are highly interested in my junior high school work.*
    B. *On the whole, I feel that they are interested in my junior high school work.*
    C. *Sometimes I feel that they are interested; sometimes I feel that they aren't.*
    D. *On the whole, I feel that they are NOT interested in my junior high school work.*
    E. *No! I am certain that my parents are NOT interested in my school work.*

13. What is your opinion of the <u>number</u> of activities--such as clubs, dances, parties, and sports--in your junior high school?

    A. I am greatly dissatisfied with the small number of activities.
    B. On the whole, I feel that we DON'T have enough activities in this school.
    C. We have a fair number of activities, but we should have more.
    D. On the whole, I feel that we have enough activities in our junior high school.
    E. I am very well satisfied with the number of activities in our junior high school.

14. When we have a science problem the teacher gives us the correct answers right away.

    A. The teacher <u>almost never</u> gives the correct answer right away.
    B. The teacher <u>seldom</u> gives the correct answer right away.
    C. The teacher sometimes gives us the correct answer right away. (about half the time)
    D. The teacher <u>often</u> gives the correct answer right away.
    E. The teacher <u>almost always</u> gives the correct answer right away.

15. What, in general, is your opinion of the teachers in your junior high school?

    A. No other junior high school has a better group of teachers than ours.
    B. I believe that we have a <u>good</u> group of teachers in our junior high school.
    C. I feel that we have an <u>average</u> group of teachers in this junior high school.
    D. I believe that we have a <u>poor</u> group of teachers in this junior high school.
    E. No other junior high school has a poorer group of teachers than this one!

16. What is your opinion of the group of subjects (or courses) that is offered in your junior high school?

    A. No junior high school student should have to study these subjects!
    B. I feel that this junior high school offers a <u>poor</u> group of subjects.
    C. This junior high school offers a <u>fair</u> group of subjects.
    D. I feel that this junior high school offers a <u>good</u> group of subjects.
    E. I couldn't ask for a better group of subjects!

17. *Do you feel that your junior high school work is the kind of work that you like to do?*

    A. *Yes! All of my junior high school work is the kind of work that I like to do.*
    B. *Most of my junior high school work is the kind of work that I like to do.*
    C. *Some of my junior high school work is the kind that I like to do; some is not.*
    D. *Little of my junior high school work is the kind of work that I like to do.*
    E. *No! None of my junior high school work is the kind of work that I like to do.*

18. *Our science teacher uses many types of teaching. (eg. discussion groups, films, overhead projector, lab exercises, etc.)*

    A. *Almost always.*
    B. *Often.*
    C. *Sometimes (about half the time).*
    D. *Seldom.*
    E. *Almost never.*

19. *Do you believe that your junior high school teachers are personally interested in you?*

    A. *No! I feel that my junior high school teachers are NOT interested in me.*
    B. *Generally I DON'T believe that they are interested in me as a person.*
    C. *Sometimes I feel that my teachers are personally interested in me.*
    D. *Generally, I believe that they are interested in me as a person.*
    E. *Yes! I definitely feel that my teachers are interested in me as a person.*

20. *In your opinion, how do people in your community feel about your junior high school?*

    A. *The people are greatly dissatisfied with this junior high school.*
    B. *Generally, they are dissatisfied with this junior high school.*
    C. *About half of the people in this community are satisfied with the school.*
    D. *Generally, they are satisfied with our junior high school.*
    E. *The people are very well satisfied with our junior high school.*

21. We perform a large variety of activities in our science class. e.g., listen to the teacher, solve problems, do lab work, work in the library, watch movies, discuss our work with other students.

    A. We almost never perform a large variety of activities.
    B. We seldom perform a large variety of activities.
    C. We sometimes perform a large variety of activities. (about half the time)
    D. We often perform a large variety of activities.
    E. We almost always perform a large variety of activities.

22. How do you feel about the way in which your junior high school subjects are taught?

    A. I feel that all of my subjects are taught in an excellent manner.
    B. On the whole, I am satisfied with the way in which they are taught.
    C. Some subjects are taught in a satisfactory manner; others are not.
    D. On the whole, I am dissatisfied with the way in which they are taught.
    E. I am highly dissatisfied with the way in which my subjects are taught.

23. What is your opinion of the help and assistance that your junior high school teachers give you with your school work?

    A. My teachers never help me.
    B. I feel that my teachers give me very little help.
    C. Sometimes my teachers give me the help that I need.
    D. My teachers usually give me help when I need it.
    E. I feel that my teachers are always very generous with their help.

24. We perform studies or parts of studies on our own with no help from the science teacher.

    A. We almost always perform science studies on our own.
    B. We often perform science studies on our own.
    C. We sometimes perform science studies on our own.
    D. We seldom perform science studies on our own.
    E. We almost never perform science studies on our own.

25. How do you feel about going to adults in your junior high school --such as teachers, principal, or counselors--to get help and advice regarding your personal problems such as how to improve your appearance, how to act on a date, what subjects to take in junior or senior high school, or how to get along with other people?

   A. I feel that I definitely would want to get help with my problem.
   B. I frequently would want to get help from an adult in my junior high school.
   C. I would want to get help with some, but not all, personal problems.
   D. I rarely would want to get help from an adult in my junior high school.
   E. I am sure that I would NOT go to anyone in this junior high school for help.

26. What is your opinion of the marking and grading system in your junior high school; that is, how do you feel about the way in which marks or grades are given?

   A. I feel that the system in this junior high school is very unsatisfactory.
   B. Generally, I feel that this school has a poor system.
   C. The system in this junior high school may be all right, but I don't like it.
   D. Generally, I feel that our junior high school has a good system.
   E. I feel that our junior high school has an excellent system.

27. How do you feel about the way in which your junior high school is organized?

   A. The organization is excellent; our school runs very smoothly.
   B. On the whole, I feel that our school is well-organized.
   C. The organization of our school is just "so-so."
   D. On the whole, I feel that this school is poorly organized.
   E. The organization is very poor; no one knows what is going on.

28. We perform lab work in which we do not know if there is a correct answer before we begin.

   A. Almost never.
   B. Seldom.
   C. Sometimes. (about half the time)
   D. Often.
   E. Almost always.

29. What is your opinion of the school spirit in your junior high school?

    A. There is absolutely NO school spirit in this junior high school.
    B. The school spirit is low.
    C. The school spirit is about average when compared with other schools.
    D. Our school spirit is high.
    E. Our school spirit is excellent! It couldn't be higher!

30. How do you feel about the social life you are having while attending junior high school?

    A. I am greatly disappointed with my social life.
    B. Generally, I am dissatisfied with my social life.
    C. Sometimes I am satisfied with my social life; sometimes I am not.
    D. Generally, I am satisfied with my social life.
    E. I am very well satisfied with my social life.

31. Do you feel that going to junior high school will help you in enjoying life more and getting more satisfaction from living?

    A. No! I am certain that going to junior high school will NOT help me.
    B. On the whole, I DON'T believe that going to junior high school will help much.
    C. Going to junior high school may be of some help to me in enjoying life.
    D. On the whole, I feel that going to junior high school will be helpful.
    E. Yes! I am sure that going to junior high school will help me in enjoying life.

32. Our teacher starts a new study by giving rules and general ideas.

    A. Our teacher almost always starts this way.
    B. Our teacher often starts this way.
    C. Our teacher sometimes starts this way.
    D. Our teacher seldom starts this way.
    E. Our teacher almost never starts this way.

33. How hard do you feel that you are working (or studying) on your school work?

    A. I never work.
    B. Usually I DON'T work very hard.
    C. Sometimes I work hard; sometimes I don't.
    D. Usually I work hard.
    E. I always work as hard as I can on my junior high school work.

34. What is your opinion of the other boys and girls in your junior high school?

A. They are the best group in the world!
B. I feel that we have a good group of boys and girls in our junior high school.
C. Some of the students are all right; some are not.
D. I feel that this junior high school has a poor group of boys and girls.
E. They are the worst group in the world!

35. How well, in your opinion, do your junior high school teachers "know" and understand the subjects that they teach?

A. My teachers definitely do NOT "know" and understand their subjects.
B. They don't "know" and understand their subjects as well as they should.
C. Some of my teachers "know" and understand their subjects; some don't.
D. Generally, I feel that they "know" and understand their subjects.
E. My teachers definitely do "know" and understand their subjects.

36. We learn about and practise the type of activities a scientist should have.

A. Almost always.
B. Often.
C. Sometimes. (about half the time)
D. Seldom.
E. Almost never.

37. What is your opinion of the equipment and facilities--such as laboratory and shop equipment, books and desks--in your junior high school?

A. No other junior high school has better equipment and facilities than ours.
B. Our equipment and facilities are better than those in most schools.
C. The equipment and facilities in our junior high school are about average.
D. Our equipment and facilities are poorer than those in most schools.
E. No other junior high school has poorer equipment and facilities than ours.

38. *In general, how well do you feel that the other people in your junior high school treat you?*

    A. *I feel that I couldn't be treated better!*
    B. *I feel that I am treated in a satisfactory manner.*
    C. *Sometimes I am treated all right; sometimes I feel that I am not.*
    D. *Generally, I feel that I am NOT treated very well.*
    E. *I feel that I couldn't be treated <u>worse</u>!*

39. *In your estimation, how good a job does your school do in educating the students who come to it?*

    A. *Outstanding.*
    B. *Very good.*
    C. *About average.*
    D. *Poor.*
    E. *Very poor.*

40. *How good a job do your teachers do in teaching you?*

    A. *Outstanding.*
    B. *Above average.*
    C. *About average.*
    D. *Below average.*
    E. *Very poor.*

41. *How well do you like the teachers, as persons, who teach you?*

    A. *I like my teachers very much.*
    B. *I like my teachers a little bit.*
    C. *I think my teachers are about average.*
    D. *I dislike my teachers a little bit.*
    E. *I dislike my teachers very much.*

42. *How good a job does your principal do as a principal?*

    A. *Outstanding.*
    B. *Above average.*
    C. *About average.*
    D. *Below average.*
    E. *Very poor.*

SATS

STUDENT ATTITUDE TOWARDS SCIENCE

FORM A - (Revised)

Dr. R. L. Hedley

DIRECTIONS

The following statements are related to your work in the science course you are taking this year. These statements are presented as generalizations and represent opinions rather than facts. As opinions, they are neither right nor wrong. This is not a test but a device to determine how you feel about your course of study. In the items that follow you are asked to give your honest opinion by scoring the appropriate section of the answer sheet with an ordinary HB pencil. Score the appropriate section as it first impresses you. Indicate <u>what you believe</u> rather than what you think you should believe.

Example: I like to watch NHL hockey broadcasts on TV.

	A 1	B 2	C 3	D 4	E 5
139.	----- -----	----- -----	----- -----	----- -----	----- -----
	strongly agree	agree	neutral	disagree	strongly disagree

If you score the A response this would indicate that you are very interested in hockey and watch the televised programs most of the time.

If you score the B response, this would indicate that you watch the TV hockey broadcasts frequently but on some nights you would watch competing programs.

If you score the C response, this would indicate that you really didn't care one way or another. You would watch hockey sometimes and just as often you would do something else.

If you score the D response, this would indicate that you watch other programs or do something else more often than you watch hockey. It would also indicate that you did watch the program once in a while.

If you score the E response, this would indicate that you do not watch hockey at all. In fact you have no interest in the hockey programs.

Now find item 139 on your answer sheet and practice answering by answering the above question. Darken in the space between the lines of your chosen answer completely. Erase completely any answers you wish to change. As well, try the following item.

Example:

140. The assignments my teacher gives me in science are usually too difficult.

Please supply the information requested on the top of the answer sheet and as well put your teacher's name on the top right-hand corner.

Reminder:

A - strongly agree B - agree C - neutral D - disagree E - strongly disagree

1. Much of the material of the science course I have already covered in Junior High School, so it is not new to me.

2. I can read the text with no difficulty. Most of the technical terms are clearly explained.

3. I would like to study many topics in the science course more deeply but there is not enough class time.

4. The topics I have studied this year in my science course are of little use to me in the work that I plan on doing after I leave school.

5. Much of the information given in my science textbook is out-of-date.

6. I like to see demonstrations of scientific principles carried out in class as it makes the text easier to understand.

7. Little consideration is given in my science course to the topics in science that I think are the important or big problems in science.

8. I think the science course I am taking is useful to me because it shows recent applications of science.

9. We have charts, clippings and other interesting materials on display in our science classroom.

10. I pay more attention in science classes than in other classes because I am interested in the topics we are studying in science.

11. Many of the laboratory exercises we performed this year were too long to be done in the allotted time.

12. In my science classes we use interesting apparatus and materials, either in the laboratory or in the classroom.

13. I think that my laboratory manual gives adequate direction so I know how to carry out the experiment.

14. I seldom know the result of an experiment before I carry out the laboratory exercise. Most of the experiments cause me to think.

15. I would rather have taken a biological science course this past year than the course of study we had.

Reminder:

A - strongly agree *B - agree* *C - neutral* *D - disagree* *E - strongly disagree*

16. *I think our laboratory was well enough equipped to do all the experiments suggested in our work this year.*

17. *When I study a topic or a unit in my science course, I can usually see why it is important for me to study it.*

18. *I have done only a few of the laboratory experiments on my own or with groups of fellow students this past year. Most of the work is demonstrated by the teacher.*

19. *I find the questions at the end of the chapters of the text that involve mathematical calculations too difficult.*

20. *I am interested in performing experiments in the laboratory but do not like having to write up the experiment in detail.*

21. *I am not interested in taking a science course like this one next year but would rather take almost any subject other than science.*

22. *I think we spent too much time in class on some topics in the science course this year and rushed too quickly over other topics.*

23. *Experiments relating to the topic I was studying in class were performed at approximately the same time as the work was studied in the regular class periods.*

24. *I would prefer to work on experiments I invented and devised rather than the ones I have done this year.*

25. *I spent too much time on learning trivial laboratory techniques which were not important to getting my experiments done.*

26. *Too much time is devoted to the study of science and not enough time to the study of other subjects.*

27. *I prefer to handle the equipment myself in doing experimental work rather than watching someone else do the experiment.*

28. *Because of my interest in science, I normally spend more time on my science homework than in other subjects.*

29. *Because of the difficulty of this science course, I find that I have to spend more time on science homework than in other subjects.*

Reminder:

A - strongly agree B - agree C - neutral D - disagree E - strongly disagree

30. I wish those who develop courses and select texts would ask me what I thought I needed to learn in science. I think I know what I would like to study for the job I want after I leave school.

31. Too much mathematics is needed to do this course in science.

32. I think the course I am studying in science is too difficult for me.

33. In general I think I am learning things from my science course that I can use.

34. I think the experiments that I have done this year have begun to make me think as I imagine a scientist thinks.

35. I am confused over such technical terms as scientific model, scientific problems, hypothesis, conclusions, laws and theories.

36. I think I can read popular articles in the general area of science with better understanding because of the information I have obtained from my science course.

37. I have read more articles in popular science books and magazines this year than I have in any single year before.

38. I like to do the extra science investigations or activities suggested in the text.

39. I find the questions at the end of the chapter challenging. They make me think.

40. Most of the topics I am taking in my science course are those I would like to study more deeply at some future time.

41. This course has helped me in some of the other courses I am taking this year.

42. I spend more time studying science than I do any other subject.

43. I think my powers of observation have improved through the work I have taken in science this year.

44. The science course covers too much material. We do not spend enough time on any one topic for me to understand it.

Reminder:

A - strongly agree   B - agree   C - neutral   D - disagree   E - strongly disagree

45. I would like to help present demonstrations to my classmates on the topics we study in science.

46. When we see demonstrations in class I find that I become more attentive and interested in the work.

47. I have to be forced to do my science homework.

48. I have to be forced to do any kind of homework. I just don't like doing any kind of assignment.

49. The text is very informative. Enough information is given on most topics so that I can understand the main ideas.

50. I would like to construct in the laboratory simple machines and simple apparatus to carry out experiments. I think this would be useful in making me think like a scientist.

51. The problems at the end of the chapter are useful and beneficial to me. They help me understand the course.

52. The author(s) of my textbook has (have) made the content interesting, easily understood, concise and clear.

53. The science course that I am taking is more difficult than the science courses that other students in this school are taking.

54. I think the text is too compact and too congested, making for heavy reading.

55. I think there are sufficient illustrations of applications of scientific principles, in examples or in diagrams, in the text of the various topics in the course we are studying.

56. I often notice in things around me application of some of the scientific principles I have studied this year.

57. I think the exercises in the text serve no useful purpose and are merely busy work.

58. I frequently read other texts and reference books in order to understand the material in my science course.

59. I like experiments for which there is a right answer so that I know the results I get are right or wrong.

Reminder:

A - strongly agree B - agree C - neutral D - disagree E - strongly disagree

60. The demonstrations I have seen this year usually have worked as I expected them to work.

61. I usually know what I am supposed to do in the laboratory.

62. I would like to have my science course organized so I could do more experimental work.

63. The knowledge I have gained in my science course gives me a feeling of accomplishment.

64. I usually look forward to my science classes.

65. In my classes, the laboratory period is a play period.

66. I believe the information I am learning in my science course is useful to me now and will be useful in later life after I finish school.

67. I can't follow the directions for doing experiments in the laboratory. They are not clear enough for me to see what I am supposed to do.

68. The text usually refers to everyday applications in science that I can understand.

69. I usually read the instructions for carrying out experimental work carefully.

70. I feel the time I spend in the laboratory doing experiments could be much better utilized.

71. In studying my science course, I am beginning to see how knowledge from one science area related to another area.

72. I believe my vocabulary of technical and scientific terms has improved considerably this year.

NUMBER 5 - TOUS

TOUS

TEST ON UNDERSTANDING SCIENCE

Form Jw

DIRECTIONS:

1. *Each of the questions or incomplete statements in this booklet is followed by four possible answers. You are to choose the one BEST answer for each question.*

2. *All of your answers are to be made on the separate answer sheet you have been given. Do not make any marks in this booklet.*

3. *Indicate your answers on the answer sheet by marking the space below the capital letter which is the same as the letter in front of the answer you choose. You may use a regular pencil to mark your answers.*

4. *You are to mark one, and only one, answer for each question. If you change your mind about an answer, erase the mark for your first answer completely and cleanly; then mark the space corresponding to the letter of your new answer.*

5. *Here is a sample:*

   50. The main reason for doing experiments in science is to

   A. check new ideas.
   B. find things out.
   C. use laboratory equipment.
   D. learn about nature.

   Choose the one BEST answer to this sample question. On the separate answer sheet, find row number "50" and mark the space below the letter of the answer you have chosen.

6. *Your answers for all the questions in this booklet should be marked in this manner on your separate answer sheet. Be sure that the number of the row you are marking and the number of the question you are answering are the SAME. If you have any questions about these directions, raise your hand. Your teacher will try to help you.*

7. *Try hard to answer all the questions in this booklet. Choose what you think is the one BEST answer for every question.*

8. *Once again, DO NOT WRITE ANYTHING IN THIS QUESTION BOOKLET.*

Please do not turn this page until you are asked to do so.

1. Which of the following is the best list of what scientists study?

   A. atoms, molecules, and stars
   B. matter, energy, and living things
   C. rockets, satellites, and space travel
   D. plants, animals, and disease

2. Which of the following is the main need of science?

   A. more money and equipment
   B. well-trained assistants
   C. better working conditions
   D. people with new ideas

3. A scientist predicted that an experiment would come out a certain way. He observed a different result when he did the experiment. What would he most likely say to himself?

   A. "I shouldn't have made a prediction before trying this out."
   B. "Something went wrong in the experiment, because I didn't observe the result I predicted."
   C. "I should have better equipment for this experiment to get the right result."
   D. "Something is wrong either with my observation, my experiment, or my prediction."

4. If you were to meet a scientist on the street, he would probably look like

   A. an eager, hurrying person.
   B. a quiet, thoughtful person.
   C. anyone else you might meet.
   D. an intelligent, young person.

5. The newest microscopes make it possible for scientists to study small objects and also to

   A. look for the meaning of life.
   B. explore many new problems.
   C. observe atoms in motion.
   D. see that germs cause disease.

6. Today, the education of American scientists who teach and do research at colleges and universities generally

   A. is completed after four years of college attendance.
   B. includes a period of practical training in some industry.
   C. is completed after two years of college or technical school.
   D. includes long study in universities after finishing college.

7. The scientists of today can work on more complex problems than the scientists of the past mainly because they

   A. work much harder than earlier scientists.
   B. have more imagination than earlier scientists.
   C. build on the work of earlier scientists.
   D. are more intelligent than earlier scientists.

8. When a scientist completes a new scientific theory, we know that he has

   A. revealed one of the laws of nature.
   B. helped to move mankind closer to absolute truth.
   C. discovered new ways to conduct experiments.
   D. developed new ideas and understanding.

9. Designing a space rocket is chiefly a problem of

   A. the application of science, because the designer produces new understandings about nature.
   B. science, because the design must be developed by experiment.
   C. the application of science, because it leads to the production of a practical device.
   D. science, because it calls for being clever and having new ideas.

10. Scientists would consider any major hypothesis to be

    A. a temporary explanation.
    B. a changeless truth.
    C. a final explanation.
    D. a temporary truth.

11. The people and government of the United States influence scientific activity

    A. very little, because scientists are quite isolated from the rest of the society.
    B. a little, because some people must be willing to become scientists and the government pays them.
    C. a great deal, because most scientists work for the government and must follow its instructions.
    D. a great deal, because the people can decide about having an educational system that can train scientists.

12. Most important scientific ideas are developed today as a result of

    A. a long investigation by a scientist working alone.
    B. a group of scientific experts deciding what to study.
    C. work and thinking carried on by many scientists.
    D. team-work between scientists and the government.

13. Betty is planning an experiment to learn something about the role of potassium in the growth of a certain plant. She decides to grow one group of these plants in soil containing nitrogen and phosphorus, but lacking potassium. A second group of these plants, serving as a "control", should be grown in soil containing

    A. potassium only.
    B. nitrogen, phosphorus, and potassium.
    C. nitrogen and potassium, but no phosphorus.
    D. nitrogen and phosphorus, but no potassium.

14. Which one of the following sentences best describes science?

    A. Science is thinking and doing.
    B. Science is observing and measuring.
    C. Science is thinking and planning.
    D. Science is experimenting.

15. When much new evidence is discovered which does not fit a scientific theory, scientists usually will ask themselves:

    A. Shall we throw out the theory, since the new evidence doesn't fit it?
    B. Can we change the evidence a little so that it will fit the theory?
    C. Shall we keep the theory as it is, since the new evidence doesn't help it?
    D. Can we change the theory a little so that this new evidence will fit it?

16. The chief purpose of the science of botany is to

    A. find out what plants grow best in various kinds of soil.
    B. understand how plants live, grow, and reproduce.
    C. develop new drugs and medicines from plants.
    D. help farmers grow bigger plants and produce more food.

17. Mary writes down all the details of her science experiments. If Mary becomes a scientist, this training will help her to

    A. be patient in doing her experiments.
    B. make better reports about her experiments.
    C. think up theories from her experiments.
    D. work out new experiments to perform.

18. When scientists in America work on a major research project today, the laboratory equipment they need usually is built by

    A. the scientists themselves.
    B. other scientists.
    C. a nearby government agency.
    D. people who are not scientists.

19. Scientists are often said to be very hard-working and dedicated to their jobs. This is true about

    A. successful people in almost all kinds of work.
    B. scientists, but not people in other kinds of work.
    C. most people in important work, but not scientists.
    D. the experimental work of a few top scientists.

20. After a scientist has found the solution to a problem in scientific research, he usually

    A. seeks a practical application for his discovery.
    B. feels that the problem is solved once and for all.
    C. cannot easily find a new problem to work on.
    D. sees that his work has opened up new problems.

21. A scientist is <u>open-minded</u> about his work if he

    A. thinks up many new ideas for experiments.
    B. discusses most of his ideas with others.
    C. considers ideas which go against his own.
    D. agrees with the ideas of other scientists.

22. *Scientists have many goals in doing scientific work, but their principal aim is to*

    A. *search out errors in what has already been discovered about the physical universe.*
    B. *explain natural phenomena in terms of principles and theories.*
    C. *discover, collect, and classify facts about living and non-living things.*
    D. *provide the people of the world with the means for leading better lives.*

23. *When a scientist reads a report of a new scientific discovery, he probably will*

    A. *not fully believe the report until he has checked the work himself.*
    B. *believe the report without asking too many questions about it.*
    C. *not fully believe the report until he has obtained more information.*
    D. *believe the report because it describes the work of scientists.*

24. *Different groups of people help mankind in different ways. What is the special way in which scientists help mankind?*

    A. *Scientists make better things for better living.*
    B. *Scientists show us how to be more healthy.*
    C. *Scientists give us knowledge about nature.*
    D. *Scientists offer skilled service and advice.*

25. *Speaking about the intelligence of scientists, we can correctly say that most scientists*

    A. *are about as intelligent as the average person.*
    B. *are born with a special scientific curiosity.*
    C. *become intelligent after getting scientific training.*
    D. *have more than average intelligence.*

26. *Ralph said: "Scientists do experiments to ask questions of nature." By this Ralph means that experiments are used in science to*

    A. *prove that nature works in a regular manner.*
    B. *learn by trying things, making mistakes, and then trying again.*
    C. *test out the ideas of scientists.*
    D. *ask about the mystery of creation.*

27. A research scientist is most likely to make important discoveries by

    A. making experimental measurements more accurate.
    B. thinking up ideas and trying experiments to test them.
    C. doing research in a very well-equipped laboratory.
    D. making many observations and reporting his results.

28. Many essays have been written about the meaning of life. Today, any serious essay on the meaning of life probably would

    A. be written by a scientist who has studied living things.
    B. include what scientists have learned about life.
    C. give a proof of the scientific theory of evolution.
    D. contain little or nothing on the scientists' ideas about life.

29. A scientist learns about a new theory that someone has suggested. Will this scientist decide to agree with the new theory? Most likely, the scientist will decide on the basis of

    A. whether or not the theory is true.
    B. the experimental evidence supporting the theory.
    C. his personal ideas and the evidence supporting the theory.
    D. whether or not the theory can be put into mathematical form.

30. Bill always does well in school, likes to build model airplanes, and plays jokes on his classmates. Frank makes high grades in mathematics, likes to read books, and plays baseball. Janet is a serious, intelligent girl and likes to dance. Who do you think could become a scientist?

    A. Bill
    B. Frank
    C. Janet
    D. Any one of the three.

31. Most scientists consider scientific theories to be

    A. changeless truths.
    B. explanations that may be revised.
    C. final explanations.
    D. descriptions of the world as it really is.

32. In trying to decide whether or not to go to a new movie, a scientist would probably ask himself:

    A. "Does the film use experimental techniques?"
    B. "Is there cause and effect in the plot?"
    C. "Will I like this film?"
    D. "Is the plot factual and accurate?"

33. When we say that a scientist forms a <u>hypothesis</u> about an experiment, we mean that he

    A. makes a careful guess about what will happen.
    B. gives directions for doing the experiment properly.
    C. suggests how to make exact measurements.
    D. describes how the experiment was carried out.

34. Scientists most often make important advances in research by

    A. trial and error and experimentation.
    B. planning and experimenting.
    C. difficult laboratory work.
    D. observing and measuring.

35. A scientific <u>law</u> describes

    A. rules which scientists must obey.
    B. relationships between events in nature.
    C. directions for doing good experiments.
    D. good guesses about how things happen.

36. A young person who wants to have a career in science would be able to find a job as a scientist

    A. only in the United States or Russia.
    B. only in countries in America and Europe.
    C. in most countries of the world.
    D. only in countries with large industries.

37. A scientific <u>theory</u> should

    A. give final answers to scientific questions.
    B. supply directions for making useful things.
    C. tie together and explain many natural events.
    D. describe the world as most scientists see it.

38. Which of the following sentences about science is best?

A. Modern science is too advanced to use past discoveries.
B. Modern science develops modern products.
C. Modern science depends on useful inventions.
D. Modern science is based on the science of the past.

39. Since science is now expanding so rapidly, you could correctly predict for the future that

A. scientists will develop new ideas.
B. there will soon be little left for scientists to discover.
C. machines will plan research projects.
D. the expansion of science cannot be stopped.

40. Some scientists specialize in developing new scientific theories. In doing this kind of work, these scientists might hardly ever

A. perform any experiments.
B. consider the theories of other scientists.
C. consider experimental evidence.
D. share their theories with other scientists.

41. Today, some scientists are employed in industry to do research on the properties of metals. The research these scientists carry out would usually

A. add to scientific knowledge but have little or no practical value.
B. add to scientific knowledge and help the industrial applications of science.
C. have many practical applications in industry but add little or nothing to scientific knowledge.
D. have many industrial applications and help scientific knowledge to become permanent truth.

42. Scientists are often said to have certain "scientific attitudes." A scientist shows these attitudes most clearly when he is

A. working on his research.
B. moving into a new laboratory.
C. doing most anything.
D. with his family and friends.

43. *Smith, a research scientist, reads a report of an experiment by Mrs. Jones, who is doing research in the same scientific field as Smith. In his own experiments, Smith has found out some important information that was not mentioned in Mrs. Jones' report. In this situation, which of the following would Smith be LEAST LIKELY to do?*

    A. *Tell Mrs. Jones the information in a letter or by phone.*
    B. *Issue a statement to the press about what was left out of Mrs. Jones' report.*
    C. *Rush a report of his own experiments to a scientific journal.*
    D. *Announce his findings at the next meeting of a scientific society.*

44. *When he has a day off, a scientist would probably NOT like to*

    A. *relax with his family.*
    B. *go to his laboratory.*
    C. *spend time on a hobby.*
    D. *go to a friend's party.*

45. *Which of the following statements about scientific theories is NOT correct?*

    A. *A scientific theory gives a description of the world as it really is.*
    B. *A scientist may reject a scientific theory if he has doubts about it.*
    C. *When there is some evidence against a scientific theory, scientists may still accept it.*
    D. *A scientific theory gives an explanation of many natural events.*

This is the end of the questions in this booklet. If you finish before time is called, please go back and check your answers.

NUMBER 6 - TEST ON THE NATURE OF SCIENCE *

M. J. Kozlow
University of Alberta

M. A. Nay
University of Alberta

PART A

Directions:

1. Each question or incomplete statement in Part A is followed by four possible answers. Read each question and decide which is the ONE best answer. Mark your answers on the separate answer sheet. Make certain that the number on the answer sheet corresponds to the number of the question that you are answering.

2. Since each question has only four alternatives, ignore column E on the answer sheet.

3. Do not write in this test booklet.

4. Read each question carefully but do not spend too much time on any one question. Answer all questions.

5. Mark only ONE answer for each question.

Example:

200. A person who dedicates his life to the study of chemistry is a

A. Biologist C. Chemist

B. Physicist D. Zoologist

Answer Sheet

	A1	B2	C3	D4	E5
200.	--	--	■	--	--

* This test was later renamed Test On Scientific Attitude (TOSA).

1. Scientists recognize that a scientific theory

   A. should not be changed when it is based on a large amount of data.
   B. may have to be changed to keep up with a rapidly changing world.
   C. may have to be changed when new observations are made.
   D. should not be changed when it explains what happens to nature.

2. A science magazine reports that a scientist produced a type of water that boils at 450°F under one atmosphere of pressure. Another scientist reading this report would probably

   A. believe the report if it was written by a highly respected scientist.
   B. disbelieve the report because he would know that water boils at 212°F under one atmosphere of pressure.
   C. do experiments to try to prove that it is wrong.
   D. neither believe nor disbelieve the report until other scientists study this problem.

3. Scientists have questioned many religious beliefs. Which one of the following best expresses the way you feel concerning this matter?

   A. When scientific theories question religious beliefs, it is better to keep the religious beliefs.
   B. I now question all of my religious beliefs since science has cast doubt on some of them.
   C. I have two separate thought compartments--one for my religious beliefs and one for scientific knowledge.
   D. I will keep my religious beliefs until scientists prove them to be wrong.

4. Imagine that you have just finished a laboratory investigation. Your measurements all agree except two. Which of the following would you do?

   A. Include the two odd measurements in your report but omit them from calculations.
   B. Adjust the two odd measurements to make them agree better with the others.
   C. Take more measurements.
   D. Use all the measurements as they are when making calculations.

5. When observations are made that do not fit an accepted scientific theory, scientists usually

   A. try to adjust the observations so that they fit into the theory.
   B. keep the theory as it is since the new observations cannot be used to improve it.
   C. try to change the theory so that these observations can be explained.
   D. discard this theory and develop a new one to explain these observations.

6. When Einstein published his theory of relativity, another famous scientist was reported to have said, "Dr. Einstein's new theory has shattered many of my scientific beliefs to smithereens!" This statement indicates that the scientist

   A. recognized that scientific knowledge is subject to change.
   B. held some wrong scientific beliefs without knowing it.
   C. did not believe in the old theory very strongly.
   D. did not have sufficient evidence to support his original beliefs.

7. Consider the following data concerning fluoridation of the public water supply:

   Fluorides help prevent cavities in children's teeth but do not help adult teeth.
   Small amounts of fluorides appear to have no long-term harmful effects.
   The easiest and cheapest way to administer fluorides is through the public water supply.
   The fluoride content of lakes and oceans is increasing as a result of fluorides in the public water supply.
   Fluorides can be put in milk for children.

   Which one of the following best describes your point of view after considering the above information?

   A. You would be against fluoridation.
   B. You would be uncertain as to which side to support.
   C. You would be in favor of fluoridation.
   D. You would lose interest in the problem because the evidence is too indefinite.

8. "Light travels as a stream of particles."
"Light travels as a wave."

If you came across these two statements in two different science books, which of the following would you do?

A. Ask your teacher to tell you which statement to accept.
B. Check other science books for statements on this topic.
C. Assume that scientists are not certain as to how light travels.
D. Accept the statement in the newer book.

9. Imagine you are living in a small town on the banks of a river not far from a large industrial city. Your town has just experienced a severe flood for the first time in its history. Some people are saying that it was caused by increased rainfall due to the smog from the nearby industry. Which one of the following best expresses your evaluation of this claim?

A. This is a popular opinion for which there is no evidence.
B. People are making this claim because of their prejudice against smog.
C. This is a valid conclusion based on sufficient evidence.
D. This is a popular opinion backed by some evidence.

10. Suppose that you and a friend both did the same experiment to determine whether or not sunlight is required for plants to produce starch. Both of you tested a leaf from a plant that had been left in the dark for two days. Then you both tested a leaf from a plant that had been left in the sunlight. Your friend found starch in both leaves. You found starch only in the leaf from the plant that had been left in the sunlight. Which one of the following would be the most reasonable thing for you to do?

A. Accept my own result because text books say that plants in the dark should not produce starch.
B. Have both of us repeat the experiment.
C. Accept the result obtained by the one of us who knows more about science.
D. Ask my teacher to decide which result should be accepted.

Questions 11 and 12 refer to the following paragraph:

Priestley and Lavoisier are often referred to as the "fathers of modern chemistry." Both of them accepted the phlogiston theory of combustion (all materials give off a substance called phlogiston when they burn). However, Lavoisier did many experiments on burning and developed our modern theory of combustion in which he said that oxygen is always involved. Priestly never accepted this theory.

11. Which one of the following is generally true about scientists, but was NOT demonstrated by Priestly in the above situation?

    A. Some scientists believe more strongly in their theories.
    B. Some scientists go overboard in demanding experimental evidence before changing their ideas.
    C. Scientists do not have to believe in new theories.
    D. Scientists accept new theories when they are consistent with experimental data.

12. Which one of the following is NOT true about Lavoisier in the above situation?

    A. He believed that his theory of combustion would not be changed.
    B. He recognized that theories are likely to change.
    C. He was prepared to consider ideas presented by others.
    D. He developed a new theory to explain new evidence.

13. Suppose you wanted to determine which types of mosquitoes cause malaria. You obtained three kinds (Types A, B, and C) and examined the digestive tracts of each for malaria parasites. You found some only in Type B mosquitoes. You concluded from this that malaria is spread by Type B but not by Types A and C mosquitoes. Which one of the following describes your conclusion?

    A. Your conclusion does not agree with the evidence.
    B. Your conclusion is valid in light of the evidence.
    C. Your conclusion is justified, but more evidence should be obtained.
    D. You did not obtain enough evidence to make a conclusion.

14. Some medical researchers say that marijuana does permanent damage to the brain, while others say that it is no more harmful than alcohol. In the light of this information, which of the following would you be inclined to do?

    A. Not smoke it because it is probably harmful.
    B. Ignore the evidence that it might be harmful and smoke it if you wanted to.
    C. Smoke it because it is probably no more harmful than alcohol.
    D. Put off any decision about smoking it until more definite knowledge is obtained about its effects.

Questions 15 and 16 refer to the following paragraph.

The German scientist, Schleiden, published a report on the origin of plant cells (1838). He made several observations on the reproductive cells of some plants and made the following statements:

> *It is an absolute law that every cell takes its origin as a very small vesicle (small bladder) and grows only slowly to its defined size. The process of cell formation which I have just described .... is that process which I was able to follow in most of the plants which I have studied. Yet many modifications of this development can be observed .... Nevertheless, the general law remains incontestable (cannot be questioned) ....*

15. *Which one of the following is generally true about scientists but was NOT demonstrated by Schleiden in the above situation?*

    A. *Scientists try to avoid making general statements based on limited data.*
    B. *Scientists are usually careful to report exactly what they observe.*
    C. *Scientists collect large amounts of data in order to develop laws of nature.*
    D. *Scientists often ignore observations if they do not quite fit into their theories.*

16. *Some aspects of Schleiden's theory were later shown to be inaccurate. The most probable reason why his theory was NOT completely accurate is that he*

    A. *was not able to obtain modern instruments to use in his investigation.*
    B. *did not make his theory explain all of his observations.*
    C. *tried to develop a theory to explain the origin of all cells.*
    D. *felt that his theory could not be questioned.*

17. *"Many people have cycles of mental depression which correspond to the phases of the moon." Which one of the following best represents your reaction to this statement?*

    A. *One should be willing to consider the possibility that there may be some truth to superstitions of this nature.*
    B. *Scientists could never prove or disprove this idea.*
    C. *It is an incorrect idea, but it is useful to many people.*
    D. *There seems to be some truth in this statement.*

18. Below are a number of points of view regarding the teaching of the theory of evolution in biology. In your opinion, this theory should be

A. omitted from the biology course.
B. presented to the class, but its controversial aspects should not be discussed.
C. discussed throughly in class with all students present.
D. discussed openly in class, but those students who do not want to listen should be permitted to leave.

Questions 19 and 20 refer to the following paragraph:

Galileo gathered much evidence on stars, motion of objects, etc. which gave rise to ideas contrary to those held by the philosophers of his time. The philosophers forced Galileo to recant some of these ideas (say he was wrong) and stopped him from practicing science.

19. Which one of the following best applies to this situation:

A. Galileo should have collected more evidence before disagreeing with the philosophers.
B. Galileo's ideas became wrong when he recanted.
C. Galileo should have avoided those investigations which led to disagreement with the philosophers.
D. Galileo was justified in questioning the beliefs of the philosophers.

20. In their treatment of Galileo, the philosophers

A. showed that they did not have a proper respect for evidence.
B. seemed to think that they knew all that there was to know.
C. were not willing to change their ideas in the face of new evidence.
D. showed all of the above characteristics.

21. Suppose you live near a large industrial plant. You find that the rose bushes in your yard die in a short while, but your lawn remains in perfect condition. You suspect that the fumes from the industrial plant are the cause. Which one of the following would be the most reasonable course of action for you to take?

A. Study the effect of the fumes on healthy rose bushes.
B. Stop growing rose bushes.
C. Start legal action against the plant for pollution control.
D. Move away from the plant.

22. During a class discussion, a friend of yours said, "The questions which are really important to man can never be solved by science." Which one of the following would probably be your reaction to this statement?

    A. Support him because friends should stick together.
    B. Not pay any attention to this statement because it is not worth thinking about.
    C. Ask him to present facts and arguments to support this statement.
    D. Support him because you believe that the statement is true.

23. A scientist has a theory for which he needs some evidence. He does experiments and finds that some of the results do not support his theory. When he reports his theory, he omits those results which do not fit. In this case, the scientist

    A. had a theory which did not have any practical value.
    B. considered several possible explanations.
    C. made his theory explain part of the experimental results.
    D. made the experimental results agree with his theory.

24. Drs. Brown, Jones, and Smith are medical researchers. Each one independently investigated the cancer-producing effect of compounds in tar on rats. Dr. Brown reported that there was no effect. Some time later, both Drs. Jones and Smith reported that these compounds were highly cancer-producing. Which one of the following was probably the MOST important reason for Dr. Brown's results?

    A. He did not consider all the evidence.
    B. He did not do a sufficient number of controlled experiments.
    C. He was in a hurry to report his results first.
    D. He did not analyze his data properely.

25. Suppose you did a chemistry experiment, but the results were not what you expected. Which one of the following would you do?

    A. Report the results which were predicted in the chemistry text.
    B. Copy the results from a friend.
    C. Report the results that you obtained.
    D. Report no results and tell the teacher that the experiment failed.

26. A boy goes skating on a pond and breaks through the ice. He is rescued and given a drink of hot chocolate by someone who is sneezing and coughing. A few days later the boy also has a cold. Which one of the following best describes the reason for the boy's cold?

A. His cold is due to falling in the cold water and getting wet.
B. He got the cold from the person who rescued him.
C. He probably had a cold coming before he went skating.
D. The reason why people get colds is not yet known for certain.

27. Which one of the following is NOT an important reason why scientists often repeat the experiments reported by other scientists?

A. A scientist could be so intent on finding a specific answer that he might subconsciously observe only what he wants to see in his experiments.
B. This helps to keep scientists careful and honest when making observations and reporting results.
C. Other scientists might give a different interpretation to the same observations.
D. The first scientist might overlook a significant variable in his experiment.

28. If a scientist had to choose between two theories, he would probably support the theory which

A. most other modern scientists feel is more likely to be correct.
B. has more practical value.
C. is based on a larger number of observations.
D. explains the available observations more satisfactorily.

29. In an experiment, students blew through limewater and noted that it turned milky. From this result, most of them concluded that their bodies give off carbon dioxide. However, one girl wrote in her notebook that since there is carbon dioxide in the air we breathe, the experiment proved nothing. Which one of the following best describes your evaluation of this situation?

A. The students were justified in making their conclusion.
B. The girl was justified in doubting the proof.
C. Neither side had sufficient grounds for their statement.
D. Both sides were partly justified in their statements.

30. "People born when certain stars are becoming more prominent show the influence of these stars in their personalities." People who believe this statement

A. probably have a special ability to understand such influences.
B. are not critical enough.
C. are more open-minded than most people.
D. have a disregard for scientific evidence.

31. When evaluating the accuracy of ideas in science texts, which one of the following is the most important?

A. How recently the book was published.
B. Whether or not the author is a scientist.
C. The extent to which the ideas have been simplified.
D. How recently the ideas were first presented.

32. If you came across a scientific idea which goes against your common sense, which one of the following would you be inclined to do?

A. Disregard the scientific idea because it is better to rely on common sense.
B. Disregard common sense because it is not as reliable as scientific study.
C. Do an experiment to see whether or not the common sense is superior to the scientific idea.
D. Try to produce a compromise between the scientific ideas and common sense.

33. Suppose you had worked several days on a chemistry experiment. You then accidentally added some sodium nitrate solution when you should have added silver nitrate. Which one of the following courses of action would you take?

A. Start over again as soon as you realize your mistake.
B. Continue with the experiment but if it doesn't turn out the way it should, start over.
C. Continue the experiment to see if the mistake makes any difference.
D. As soon as you realize your mistake, add some silver nitrate solution and continue with the experiment.

34. When Arrhenius first proposed his theory of ionization (salts break up into ions when they dissolve in water), very few scientists were willing to support it. Which one of the following is the MOST probable reason for this disagreement.

    A. Arrhenius gave a different interpretation to the observations related to this problem.
    B. The scientists who would not support this theory were not as imaginative as Arrhenius.
    C. Arrhenius did not have enough evidence to support his theory.
    D. The scientists who would not support this theory were less willing to risk criticism.

35. A scientist was studying an ore from the moon in an attempt to obtain a new metal from it. He made several tests but he did not find evidence of a new metal. However, he did identify a peculiar gas which he obtained during one of the tests. He probably would have

    A. reported that the ore did not contain a new metal.
    B. reported that portion of his investigation related to the gas.
    C. not made any report because he did not solve his problem.
    D. not made any report until he was able to get another scientist to confirm his identification of the gas.

36. A missionary reported that the root of a plant much like the Rauwolfia plant had been used by an African witch doctor to cure him of a serious illness. Recent medical reports show that reserpine, a drug effective in lowering blood pressure, is extracted from Rauwolfia. Which one of the following is the most reasonable conclusion that can be drawn from the above discussion?

    A. Since the witch doctor probably did not know anything about modern drugs, he did not have a scientific reason for using the roots.
    B. The plant was probably not helpful because the missionary had no way of knowing what caused him to get better.
    C. The plant may have been helpful since the missionary recovered after the witch doctor's treatment.
    D. The plant probably was helpful because the Rauwolfia plant contains reserpine.

37. Quite often it is possible to give several different explanations for a particular set of observations. Which one of the following would NOT be generally true about such explanations?

A. Only one of these explanations could be the true scientific explanation.
B. All other things being equal, the explanation which is the most widely known is likely to be the accepted one.
C. The explanation which suggests the greatest possibility for further study is likely to be the one which most scientists use.
D. All these explanations would be acceptable if they explain the observations.

38. Quite often two groups of scientists will support opposing theories about some aspect of science. Which one of the following would be the MOST important point to consider in settling such a controversy.

A. Both theories give satisfactory explanations for the observations related to the problem, but one theory has more practical applications.
B. One group of scientists believe more strongly in their theory.
C. One group contains several scientists who have won the Nobel Prize for science.
D. Different conclusions are reached when the two theories are applied to certain problems.

39. A scientist shows that he is open-minded when he

A. discusses his ideas with other scientists.
B. evaluates ideas which do not agree with his theories.
C. agrees with the ideas presented by other scientists.
D. asks other scientists to provide experimental evidence to support their arguments.

40. *Theories in science are generally accepted when it can be shown that they explain all of the related observations. However, it is possible that exceptions to the theory may exist but are still undiscovered. Which one of the following is the BEST approach to this problem?*

   A. *The limits under which the theory has been shown to apply should be carefully stated and the theory should be used within these limits.*
   B. *Scientists should provide several theories to explain a given set of observations so that if exceptions to one theory are found, they will have others to rely on.*
   C. *Scientists should not accept a theory until they are certain that exceptions to it do not exist.*
   D. *When exceptions are discovered, scientists should abandon the theory and look for a new one.*

SCIENCE LEARNING SITUATION INVENTORY (SLSI) - TEACHER'S

Prepared by Gary Gay

Following are descriptions of several science learning situations. Evaluate each situation in terms of the degree to which it describes your science learning situation and you.

On the specially prepared answer sheet, for each science learning situation mark

A. If you strongly agree with the statement. (i.e., it describes you or your science learning situation to a high degree).

B. If you agree with the statement.

C. If you neither agree nor disagree.

D. If you disagree with the statement.

E. If you strongly disagree with the statement. (i.e., it does not describe your science learning situation at all).

Please put your name and number on the answer sheet and mark your number in the first three lines of the box in the top right-hand corner.

The situations begin below.

Key:	A	B	C	D	E
	strongly agree	agree	neutral	disagree	strongly disagree

1. In some science classes the teacher spends most of the time telling the students about science or lecturing to them.

2. In some science classes the science teacher causes the students to think when he talks to them.

3. In some science classes the teacher exemplifies or acts like a scientist would act when he is confronted with a problem.

4. Some science classrooms are organized in such a way that a lot of time is available for students to perform investigations.

5. Some science teachers are like scientists in the way they do things.

6. When a student asks some science teachers a question they get questions in return, others supply the answer immediately. I give an immediate direct answer.

Key:	A	B	C	D	E
	strongly agree	agree	neutral	disagree	strongly disagree

7. In some classes a wide variety of techniques are used to solve problems in science and to learn about science. (Examples: discussions, field trips, lectures, movies, lab, library, etc.)

8. Some science classes spend considerable time learning about the types of attitudes a scientist should have.

9. In some science classes the students help set up equipment for demonstrations and assist in performing them.

10. Some science classes spend time developing hypotheses or guessing possible answers to a given problem.

11. Some science classes spend time designing experiments which could be used to help find the solution to a given problem.

12. Some science classes spend time collecting data which may be of use in solving a particular problem.

13. Some science classes spend time organizing, analyzing and interpreting data collected in a given experiment.

14. In some science classes the student is expected to work towards his own answer to a scientific problem rather than a "correct" answer which the teacher expects.

15. In some science classes students get to choose their own experiments at least part of the time.

16. In some science classes students are motivated to discuss collected data, ideas, hypotheses, procedures, data processing, etc. with other students.

17. The students spend more time working and doing things than the science teacher actually does talking to them.

18. The students get to study topics that are of interest to them.

19. There are definite answers or conclusions that the science teacher expects for experiments or lab work.

20. The students perform a large variety of activities in their science class. e.g., listen to the teacher, solve problems, do lab work, work in the library, watch movies, discuss their work with other students, etc.

Key:	A	B	C	D	E
	strongly agree	agree	neutral	disagree	strongly disagree

21. The students perform studies or parts of studies on their own with little or no help from the science teacher.

22. The students perform lab work in which they do not know if there is a correct answer before they begin.

23. The teacher starts a new study by giving rules and general ideas.

24. The students learn science in a manner similar to the way in which scientists learn about science.

25. As a result of learning science the students understand better what scientists are doing in the world today.

26. As a result of learning science the students appear more interested in the latest developments of science as reported in newspapers or magazines.

27. The students spend time on their own outdoors or at home collecting data or information that is of interest to them in science.

28. In class the students often analyze current newspaper or magazine articles to see what the scientists are actually planning and doing.

29. When students read articles in newspapers and magazines or hear news about scientists on the radio they think about what stage of planning the scientists' experiments are in.

30. The students spend time in class just investigating the activities scientists participate in rather than just the knowledge they discover.

31. The students view the lab, the classroom, the library, outside the school and other teachers all as possible sources of information for their science studies.

32. The students learn, in their science classes, desirable ways to attack new scientific problems.

33. The students know why scientists are going to the moon.

34. As a result of studying science the students know, and know how to perform, the important steps in solving a scientific problem.

35. The students could attack and propose a solution to a new problem using a scientific method.

Key:	A	B	C	D	E
	strongly agree	agree	neutral	disagree	strongly disagree

36. As a result of the manner in which the class studies science the students should feel as if they are acting like a scientist a large proportion of the time.

37. As the students study science they are learning a method they can use to study and solve new science and personal problems which may arise.

38. The science class often spends considerable time discussing the results of experiments with little advice from the teacher.

Thank you for your cooperation in filling in this Science Learning Situation Inventory.

SCIENCE LEARNING SITUATION INVENTORY (SLSI) - TEACHER'S ASSOCIATE

Prepared by Gary Gay

Following are descriptions of several science learning situations. Evaluate each situation in terms of the degree to which you think it describes the science learning situation and/or the teacher who gave it to you.

On the specially prepared answer sheet, for each science learning situation mark

A. If you strongly agree with the statement. (i.e., it describes the teacher or his science learning situation to a high degree).

B. If you agree with the statement.

C. If you neither agree nor disagree.

D. If you disagree with the statement.

E. If you strongly disagree with the statement. (i.e., it does not describe the science learning situation at all).

The situations begin below.

Key:	A	B	C	D	E
	strongly agree	agree	neutral	disagree	strongly disagree

1. In some science classes the teacher spends most of the time telling the students about science or lecturing to them.

2. In some science classes the science teacher causes the students to think when he talks to them.

3. In some science classes the teacher exemplifies or acts like a scientist would act when he is confronted with a problem.

4. Some science classrooms are organized in such a way that a lot of time is available for students to perform investigations.

5. Some science teachers are like scientists in the way they do things.

6. When a student asks some science teachers a question they get questions in return, others supply the answer immediately. The teacher you are concerned with here gives an immediate direct answer.

Key:	A	B	C	D	E
	strongly agree	agree	neutral	disagree	strongly disagree

7. In some classes a wide variety of techniques are used to solve problems in science and to learn about science. (Examples: discussions, field trips, lectures, movies, lab, library, etc.)

8. Some science classes spend considerable time learning about the types of attitudes a scientist should have.

9. In some science classes the students help set up equipment for demonstrations and assist in performing them.

10. Some science classes spend time developing hypotheses or guessing possible answers to a given problem.

11. Some science classes spend time designing experiments which could be used to help find the solution to a given problem.

12. Some science classes spend time collecting data which may be of use in solving a particular problem.

13. Some science classes spend time organizing, analyzing and interpreting data collected in a given experiment.

14. In some science classes the student is expected to work towards his own answer to a scientific problem rather than a "correct" answer which the teacher expects.

15. In some science classes students get to choose their own experiments at least part of the time.

16. In some science classes students are motivated to discuss collected data, ideas, hypotheses, procedures, data processing, etc. with other students.

17. The students spend more time working and doing things than the science teacher actually does talking to them.

18. The students get to study topics that are of interest to them.

19. There are definite answers or conclusions that the science teacher expects for experiments or lab work.

20. The students perform a large variety of activities in their science class. e.g., listen to the teacher, solve problems, do lab work, work in the library, watch movies, discuss their work with other students, etc.

Key:	A	B	C	D	E
	strongly agree	agree	neutral	disagree	strongly disagree

21. The students perform studies or parts of studies on their own with little or no help from the science teacher.

22. The students perform lab work in which they do not know if there is a correct answer before they begin.

23. The teacher starts a new study by giving rules and general ideas.

24. The students learn science in a manner similar to the way in which scientists learn about science.

25. As a result of learning science the students understand better what scientists are doing in the world today.

26. As a result of learning science the students appear more interested in the latest developments of science as reported in newspapers or magazines.

27. The students spend time on their own outdoors or at home collecting data or information that is of interest to them in science.

28. In class the students often analyze current newspaper or magazine articles to see what the scientists are actually planning and doing.

29. When students read articles in newspapers and magazines or hear news about scientists on the radio they think about what stage of planning the scientists' experiments are in.

30. The students spend time in class just investigating the activities scientists participate in rather than just the knowledge they discover.

31. The students view the lab, the classroom, the library, outside the school and other teachers all as possible sources of information for their science studies.

32. The students learn, in their science classes, desirable ways to attack new scientific problems.

33. The students know why scientists are going to the moon.

34. As a result of studying science the students know, and know how to perform, the important steps in solving a scientific problem.

35. The students could attack and propose a solution to a new problem using a scientific method.

Key:	A	B	C	D	E
	strongly agree	agree	neutral	disagree	strongly disagree

36. As a result of the manner in which the class studies science the students should feel as if they are acting like a scientist a large proportion of the time.

37. As the students study science they are learning a method they can use to study and solve new science and personal problems which may arise.

38. The science class often spends considerable time discussing the results of experiments with little advice from the teacher.

Thank you for your co-operation in filling in this Science Learning Situation Inventory.

Please enclose this and your answer sheet in the stamped, addressed envelope you were given and mail.

APPENDIX G

SLSI-S FACTORS AND CONSTITUENT ITEMS

FACTOR 1: The Scientist and the Nature of Science (15 items)

47. We learn about and practice the type of attitudes a scientist should have.

49. As a result of learning science I understand better what scientists are doing in the world today.

50. As a result of learning science I am more interested in the latest developments of science as reported in newspapers or magazines.

51. I spend time on my own outdoors or at home collecting data or information that is of interest to me in science.

52. In class we often analyze current newspaper or magazine articles to see what the scientists are actually planning and doing.

53. When I read articles in newspapers and magazines or hear news about scientists on the radio I think about what stage of planning their experiments are in.

54. We spend time in class just investigating the activities scientists participate in rather than just the knowledge they discover.

55. I view the lab, the classroom, the library, outside the school and other teachers all as possible sources of information for my science studies.

56. We learn, in our science classes, desirable ways to attack new scientific problems.

57. I know why scientists are going to the moon.

58. As a result of studying science I believe I know, and know how to perform, the important steps in solving a scientific problem.

59. I could attack and propose a solution to a new problem using a scientific method.

60. As a result of the manner in which our class studies science I feel as if I'm acting like a scientist a large proportion of the time.

Factor 1 (Cont'd)

61. As I study science I feel I am learning a method I can use to study and solve new science and personal problems which may arise.

62. Our science class often spends considerable time discussing the results of experiments with little advice from the teacher.

FACTOR 2: TMC: Variety of Activities (10 items)

Some science classrooms are organized in such a way that a lot of time is available for students to perform investigations.

8. I am in that type of class.

In some classes a wide variety of techniques are used to solve problems in science and to learn about science. (Examples: discussions, field trips, lectures, movies, lab, library, etc.)

14. I am in such a class.

15. The approaches my teacher uses to teach me about science are very effective.

In some science classes the students help set up equipment for demonstrations and assist in performing them.

19. I am in such a class.

Some science classes spend time organizing, analyzing and interpreting data collected in a given experiment.

30. We do spend time organizing, analyzing and interpreting data in our class.

In some science classes students are motivated to discuss collected data, ideas, hypotheses, procedures, data processing, etc. with other students.

37. I am in such a class.

39. We get to study topics that are of interest to us.

42. Our science teacher uses many types of teaching. (e.g., discussion groups, films, overhead projectors, lab exercises, etc.).

43. We perform a large variety of activities in our science class. (e.g., listen to the teacher, solve problems, do lab work, work in the library, watch movies, discuss our work with other students, etc.)

Factor 2 (Cont'd)

56. We learn, in our science classes, desirable ways to attack new scientific problems.

FACTOR 3: TMC: Attention to the Process of Science (10 items)

Some science classes spend time developing hypotheses or guessing possible answers to a given problem.

21. Our class does spend time developing hypotheses.

22. I spend time developing hypotheses.

Some science classes spend time designing experiments which could be used to help find the solution to a given problem.

24. Our class does spend time designing experiments.

25. I spend time designing experiments.

Some science classes spend time collecting data which may be of use in solving a particular problem.

27. We do spend time collecting data in our class.

28. I get to spend time collecting data in my class.

Some science classes spend time organizing, analyzing and interpreting data collected in a given experiment.

29. I would like to be in such a class.

30. We do spend time organizing, analyzing and interpreting data in our class.

31. I spend time organizing, analyzing and interpreting data.

In some science classes students are motivated to discuss collected data, ideas, hypotheses, procedures, data processing, etc. with other students.

37. I am in such a class.

FACTOR 4: SLSI-D: Desired Learning Environment (13 items)

In some science classes the science teacher causes the students to think when he talks to them.

3. I would like to be in that type of class.

In some science classes the teacher exemplifies or acts like a scientist would act when he is confronted with a problem.

5. I would like to be in that type of class.

Some science classrooms are organized in such a way that a lot of time is available for students to perform investigations.

7. I would like to be in that type of class.

Some science teachers are like scientists in the way they do things.

9. I would like my science teacher to be like that.

In some classes a wide variety of techniques are used to solve problems in science and to learn about science. (Examples: discussions, field trips, lectures, movies, lab, library, etc.)

13. I would like to be in such a class.

In some science classes the students help set up equipment for demonstrations and assist in performing them.

18. I would like to be in such a class.

Some science classes spend time developing hypotheses or guessing possible answers to a given problem.

20. I would like to be in such a class.

Some science classes spend time designing experiments which could be used to help find the solution to a given problem.

23. I would like to be in such a class.

Some science classes spend time collecting data which may be of use in solving a particular problem.

26. I would like to be in such a class.

Some science classes spend time organizing, analyzing and interpreting data collected in a given experiment.

29. I would like to be in such a class.

In some science classes the student is expected to work towards his own answer to a scientific problem rather than a "correct" answer which the teacher expects.

32. I would like to be in such a class.

In some science classes students get to choose their own experiments at least part of the time.

34. I would like to be in such a class.

In some science classes students are motivated to discuss collected data, ideas, hypotheses, procedures, data processing, etc. with other students.

36. I would like to be in such a class.

FACTOR 5: The Scientist (8 items)

In some science classes the science teacher causes the students to think when he talks to them.

4. I am in that type of class.

In some science classes the teacher exemplifies or acts like a scientist would act when he is confronted with a problem.

5. I would like to be in that type of class.

6. I am in that type of class.

Some science teachers are like scientists in the way they do things.

9. I would like my science teacher to be like that.

10. My science teacher is like that.

Some science classes spend considerable time learning about the types of attitudes a scientist should have.

17. I am in such a class.

47. We learn about and practice the type of attitudes a scientist should have.

48. We learn science in a manner similar to the way in which scientists learn about science.

FACTOR 6: Doing Science (11 items)

Some science classrooms are organized in such a way that a lot of time is available for students to perform investigations.

8. I am in that type of class.

Some science classes spend considerable time learning about the types of attitudes a scientist should have.

16. I would like to be in such a class.

Some science classes spend time designing experiments which could be used to help find the solution to a given problem.

25. I spend time designing experiments.

In some science classes the student is expected to work towards his own answer to a specific problem rather than a "correct" answer which the teacher expects.

33. I am in such a class.

In some science classes students get to choose their own experiments at least part of the time.

35. I am in such a class.

38. We spend more time working and doing things than the science teacher actually does teaching.

39. We get to study topics that are of interest to us.

44. We perform studies or parts of studies on our own with no help from the science teacher.

45. We perform lab work in which we do not know if there is a correct answer before we begin.

54. We spend time in class just investigating the activities scientists participate in rather than just the knowledge they discover.

62. Our science class often spends considerable time discussing the results of experiments with little advice from the teacher.

FACTOR 7: Teacher Response (6 items)

In some science classes the teachers spend most of the time telling the students about science or lecturing to them.

1. I would like to be in that type of class.

2. I am in that type of class.

When you ask some science teachers a question you get questions in return, others supply the answer immediately.

11. I would like a science teacher that gives an immediate direct answer.

12. I have a science teacher that gives an immediate direct answer to my questions, rather than one who asks questions which lead to the answer.

Some science classes spend considerable time learning about the types of attitudes a scientist should have.

16. I would like to be in such a class. (Negative loading)

41. When we have a science problem the teacher gives us the correct answer right away.

UNLOADED ITEMS

40. There are definite answers or conclusions to our experiments or lab work.

46. Our teacher starts a new study by giving rules and general ideas.

APPENDIX H

COMPARISON OF TEST STATISTICS IN RELATION TO MODE OF REPRESENTING THE RESPONDENTS

	Mode of Representation								
	Group 1: Teacher-Classroom			Group 2: Total Student Population Used in the Study			Group 3: Sample of the Student Population		
	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.
Predictor Measures									
SLSI-TMC (46 items)	110	132.3	9.5	4479	132.0	18.4	482	128.6	16.6
SLSI-ACTUAL (21 items)	110	63.0	5.5	4479	63.0	10.2	482	61.6	9.9
SLSI-DESIRE (16 items)	110	56.5	2.4	4479	56.3	7.1	482	56.8	7.2
SLSI-T (38 items)	64	131.0	14.4	--	131.0	--	(457)[a]	135.9	8.3
SLSI-TA (38 items)	36	133.0	14.2	--	133.0	--	(416)[a]	135.1	9.9

Test Statistics .... the Respondents (Cont'd)

	Mode of Representation								
	Group 1: Teacher-Classroom			Group 2: Total Student Population Used in the Study			Group 3: Sample of the Student Population		
	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.
Criterion Measures									
HIFAMS	105	129.4	6.3	4259	130.0	13.9	471	132.2	12.5
TOSA	84	15.7	8.6	3425	14.9	4.9	404	15.9	4.5
SCIENCE MARK	79	59.4	5.6	3121	59.0	15.0	482	61.4	14.0
I.Q.	72	106.0	5.0	3121	105.6	12.5	457	106.9	12.1
TOUS-Ew	82	20.5	1.9	3634	20.6	5.3	473	21.5	4.9
TOUS-Jw	68	22.4	2.6	2829	22.5	6.8	439	24.1	6.4
SATS	91	205.1	10.1	3829	205.6	24.2	477	206.5	25.0
STEP				465	38.8	8.6	306	38.9	8.6

[a] SLSI-T and SLSI-TA scores were assigned to each student as recorded for his or her teacher.

APPENDIX I

STATISTICS FOR MEASURING INSTRUMENTS USING

TOTAL STUDENT POPULATION

INSTRUMENT NAME	MEAN	STANDARD DEVIATION	RANGE	NUMBER OF STUDENTS
SLSI-S: TMC	131.62	18.40	65-205	4479
SLSI-A	62.95	10.17	24-101	4479
SLSI-D	56.28	7.14	22-79	4479
SLSI-T	(130.77)			
SLSI-TA	(132.69)			
HIFAMS TOTAL	129.69	13.80	65-187	4259
F1: SCHOOL OFFERS	24.70	4.32	8-37	4259
F2: TEACHER IMPORTANCE	27.39	4.40	8-40	4259
F3: PROGRAM IMPORTANCE	29.98	4.35	13-44	4259
F4: TEACHER CHARACTERISTICS	15.44	3.09	5-25	4259
F5: TMC	11.11	2.74	4-20	4259
F6: SOCIAL LIFE	13.60	2.17	4-20	4259
F7: SCHL PROF.	25.70	4.16	8-40	4259
F8: SYSTEM EFFECT.	18.10	2.71	8-27	4259
TOSA	14.94	4.88	0-29	3425
TOSA-CCS	6.94	2.78	0-16	3425
TOSA-ICS	7.99	2.94	0-18	3425
SCIENCE MARK	59.0	14.98	15-95	3121
I.Q.	105.64	12.46	62-150	3121

Statistics For .... Student Population

INSTRUMENT NAME	MEAN	STANDARD DEVIATION	RANGE	NUMBER OF STUDENTS
TOUS-Ew	20.57	5.30	0-33	3634
TOUS-Jw	22.47	6.78	0-41	2829
SATS	205.57	24.42	94-304	3892
STEP	38.92	8.56		306

APPENDIX J

STATISTICS FOR MEASUREMENT INSTRUMENTS USING

STUDENTS FROM SAMPLE

INSTRUMENT NAME	MEAN	STANDARD DEVIATION	NUMBER OF STUDENTS
SLSI-S	128.50	16.60	482
SLSI-A	61.62	9.89	482
SLSI-D	56.75	7.18	482
SLSI-T	(133.00)	(8.88)	(6)
SLSI-TA	(129.20)	(9.98)	(5)
HIFAMS TOTAL	132.23	14.23	471
F1: SCHOOL OFFERS	26.52	4.04	471
F2: TEACHER IMPORTANCE	28.11	4.39	471
F3: PROGRAM IMPORTANCE	30.53	4.20	471
F4: TEACHER CHARACTERISTICS	15.93	2.98	471
F5: TMC	10.38	2.62	471
F6: SOCIAL LIFE	13.67	2.20	471
TOSA	15.88	4.49	404
TOSA-CCS	7.50	2.63	404
TOSA-ICS	8.37	2.74	404
SCIENCE MARK	61.41	13.95	482
I.Q.	106.91	12.08	457
TOUS-Ew	21.46	4.88	473
TOUS-Jw	24.12	6.35	439

Statistics For .... From Sample

INSTRUMENT NAME	MEAN	STANDARD DEVIATION	NUMBER OF STUDENTS
SATS	206.50	24.83	477
STEP	38.92	8.56	306
SEX	1.52	0.50	491

APPENDIX K

ANALYSIS OF VARIANCE ON I.Q. FOR THE FOUR TREATMENT GROUPS BASED ON DEGREE OF BEING MATCHED TO THE SCIENCE LEARNING SITUATION

						Bartlett-Box Tests of Homogeneity of Group Variances	
Source	S.S.	df	M.S.	F-Ratio	Prob.	CHISQ	Prob.
Effects	1682.33	3	560.78	3.75	0.01	3.95	0.27
Errors	29581.00	198	149.40				

APPENDIX L

SCHEFFE MULTIPLE COMPARISONS OF SCORES ON SLSI-S SUBTESTS FOR THE FOUR GROUPS FROM TABLE 37

DEPENDENT VARIABLE	G I	-	G J	CONTRASTS	VARIANCES	LOWER	UPPER	F-VALUE	P-VALUE
1. A-Scores	G 2	-	G 1	-0.71	0.004	-0.88	-0.54	46.78	<0.001
	G 3	-	G 1	0.45	0.004	0.28	0.62	19.06	<0.001
	G 3	-	G 2	1.16	0.004	0.99	1.33	124.64	<0.001
	G 4	-	G 1	-0.62	0.004	-0.79	-0.45	35.24	<0.001
	G 4	-	G 2	0.09	0.004	-0.07	0.26	0.79	0.50
	G 4	-	G 3	-1.08	0.004	-1.24	-0.90	105.30	<0.001
2. D-Scores	G 2	-	G 1	0.26	0.002	0.13	0.39	11.48	<0.001
	G 3	-	G 1	1.00	0.002	0.87	1.13	166.08	<0.001
	G 3	-	G 2	0.73	0.002	0.60	0.86	87.93	<0.001
	G 4	-	G 1	1.22	0.002	1.09	1.35	242.05	<0.001
	G 4	-	G 2	0.95	0.002	0.82	1.08	145.36	<0.001
	G 4	-	G 3	0.21	0.002	0.09	0.34	7.79	<0.001
3. D - A Scores	G 2	-	G 1	0.98	0.003	0.82	1.13	108.75	<0.001
	G 3	-	G 1	0.55	0.003	0.39	0.70	34.94	<0.001
	G 3	-	G 2	-0.43	0.003	-0.58	-0.27	20.91	<0.001
	G 4	-	G 1	1.84	0.003	1.69	1.99	383.71	<0.001
	G 4	-	G 2	0.86	0.003	0.70	1.01	82.35	<0.001
	G 4	-	G 3	1.29	0.003	1.13	1.44	188.61	<0.001

APPENDIX M

SCHEFFE MULTIPLE COMPARISONS OF SCORES ON SLSI-S SUBTESTS: I.Q. AS COVARIATE

DEPENDENT VARIABLE	G I	-	G J	CONTRASTS	VARIANCES	LOWER	UPPER	F-VALUE	P-VALUE
1. A-Score	G 2	-	G 1	-0.70	0.004	-0.88	-0.53	44.31	<0.001
	G 3	-	G 1	0.45	0.004	0.27	0.62	17.56	<0.001
	G 3	-	G 2	1.16	0.004	0.98	1.33	120.88	<0.001
	G 4	-	G 1	-0.60	0.004	-0.77	-9.42	30.09	<0.001
	G 4	-	G 2	0.10	0.004	-0.06	0.28	1.00	0.39
	G 4	-	G 3	0.10	0.004	-1.22	-0.87	97.90	<0.001
2. D-Score	G 2	-	G 1	0.27	0.002	0.14	0.40	12.50	<0.001
	G 3	-	G 1	0.99	0.002	0.86	1.12	156.84	<0.001
	G 3	-	G 2	0.71	0.002	0.59	0.84	85.62	<0.001
	G 4	-	G 1	1.22	0.002	1.08	1.35	228.83	<0.001
	G 4	-	G 2	0.94	0.002	0.81	1.07	141.55	<0.001
	G 4	-	G 3	0.22	0.002	0.09	0.35	8.16	<0.001
3. D - A Scores	G 2	-	G 1	0.98	0.003	0.83	1.14	108.53	<0.001
	G 3	-	G 1	0.54	0.003	0.38	0.70	32.45	<0.001
	G 3	-	G 2	-0.44	0.003	-0.59	-0.28	22.09	<0.001
	G 4	-	G 1	1.82	0.003	1.66	1.98	349.94	<0.001
	G 4	-	G 2	0.83	0.003	0.67	0.99	76.22	<0.001
	G 4	-	G 3	1.27	0.003	1.12	1.43	182.19	<0.001

APPENDIX N

ANALYSIS OF COVARIANCE ON CRITERION MEASURES FOR THE FOUR

TREATMENT GROUPS: I.Q. AS COVARIATE

DEPENDENT VARIABLE	SOURCE					BARTLETT-BOX TESTS OF HOMOGENEITY OF GROUP VARIANCES	
	S.S.	D.F.	M.S.	F-RATIO	PROB.	CHISQ	PROB.
HIFAMS TOTAL						0.17	0.98
Effects	5031.37	3.	1677.12	9.52	<0.001		
Cov 1	52.45	1.	52.45	0.29	0.59		
Errors	33820.00	192.	176.14				
F1: SCHOOL OFFERS						0.36	0.95
Effects	302.61	3.	100.87	0.29	<0.001		
Cov 1	0.08	1.	0.08	0.00	0.94		
Errors	3076.62	192.	16.02				
F2: TEACHER IMPORTANCE						7.81	0.05
Effects	298.00	3.	99.33	5.72	<0.001		
Cov 1	0.00	1.	0.00	0.00	0.095		
Errors	3333.75	192.	17.36				
F3: PROGRAM IMPORTANCE						1.08	0.78
Effects	143.92	3.	47.97	3.25	0.02		
Cov 1	11.98	1.	11.98	0.81	0.37		
Errors	2826.43	192.	14.72				

Analysis of Covariance .... I.Q. as Covariate (Cont'd)

DEPENDENT VARIABLE	SOURCE					BARTLETT-BOX TESTS OF HOMOGENEITY OF GROUP VARIANCES	
	S.S.	D.F.	M.S.	F-RATIO	PROB.	CHISQ.	PROB.
F4: TEACHER CHARACTERISTICS							
Effects	152.78	3.	50.92	6.52	<0.001	1.38	0.71
Cov 1	2.13	1.	2.13	0.27	0.60		
Errors	1497.99	192.					
F5: TMC							
Effects	387.77	3.	129.25	22.08	<0.001	5.35	0.15
Cov	26.48	1.	26.48	4.52			
Errors	1123.87	192.	5.85				
F6: SOCIAL LIFE							
Effects	23.66	3.	7.88	1.56	0.20	4.67	0.20
Cov 1	2.76	1.	2.76	0.54	0.46		
Errors	968.10	192.	5.04				
SATS							
Effects	25963.84	3.	8654.61	17.42	<0.001	2.31	0.51
Cov 1	394.58	1.	349.58	0.70	0.40		
Errors	95378.00	192.	496.76				
SCIENCE MARK							
Effects	2290.40	3.	763.46	6.03	<0.001	5.63	0.13
Cov 1	6084.13	1.	6084.13	48.06	<0.001		
Errors	24304.00	192.	126.57				

Analysis of Covariance .... I.Q. as Covariate (Cont'd)

DEPENDENT VARIABLE	SOURCE					BARTLETT-BOX TESTS OF HOMOGENEITY OF GROUP VARIANCES	
	S.S.	D.F.	M.S.	F-RATIO	PROB.	CHISQ	PROB.
STEP							
Effects	85.08	3.	28.36	0.69	0.56	12.98	<0.01
Cov 1	2190.43	1.	2190.43	53.39	<0.001		
Errors	2994.87	73.	41.02				
TOSA TOTAL							
Effects	18.61	3.	6.20	0.40	0.75	2.93	0.40
Cov 1	229.44	1.	229.44	15.08	<0.001		
Errors	1110.39	73.	15.21				
TOSA-CCS							
Effects	3.91	3.	1.30	0.25	0.86	2.23	0.53
Cov 1	80.87	1.	80.87	15.72	<0.001		
Errors	375.39	73.	5.14				
TOSA-ICS							
Effects	11.83	3.	3.94	0.64	0.59	4.39	0.22
Cov 1	37.87	1.	37.87	6.15	0.02		
Errors	449.45	73.	6.15				
TOUS-Ew							
Effects	53.39	3.	17.79	1.24	0.30	8.10	0.04
Cov	459.87	1.	459.87	32.09	<0.001		
Errors	1046.04	63.	14.32				

Analysis of Covariance .... I.Q. as Covariate (Cont'd)

DEPENDENT VARIABLE	SOURCE					BARTLETT-BOX TESTS OF HOMOGENEITY OF GROUP VARIANCES	
	S.S.	D.F.	M.S.	F-RATIO	PROB.	CHISQ	PROB.
TOUS-Jw							
Effects	60.36	3.	20.12	0.72	0.54	7.50	0.06
Cov 1	854.20	1.	854.20	30.72	<0.001		
Errors	2029.65	73.	27.80				

APPENDIX O

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